Estimating the Effects of Introducing a Minimum 130mm Mesh Regulation on the 4X Groundfish Fishery

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ESTIMATING THE EFFECTS OF INTRODUCING A MINIMUM 130 mm MESH REGULATION ON THE 4X GROUNDFISH FISHERY

by

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ABSTRACT

Waldron, D.E., T.D. Iles, and G.V. Hurley. 1985. Estimating the Effects of Introducing a Minimum 130 mm Mesh Regulation on the 4X Groundfish Fishery. Can. Tech. Rep. Fish. Aquat. Sci. No. 1400.

A study of a Department of Fisheries and Oceans uniform otter trawl mesh size regulation for the Canadian Economic Zone was started in the spring of 1982. An observer program was used to collect data on the mesh size currently used in the impact of the mesh size increase on the industry located in the southwestern portion of Nova Scotia an area which the Department felt would be most affected by such a change. The study showed that 50% of the sampled vessels used mesh sizes very close to the proposed mesh size of 130 mm. The calculated immediate loss in haddock catch to the fishery was unevenly proportioned amongst the fleets studied. Small vessels in St. Mary's Bay were observed to use codend mesh sizes less than the current 120 mm regulation. As a result of an increase in codend mesh to 130 mm these vessels could lose 70% of their haddock catch and a substantial proportion of their primary fishery, flounders. An exemption to the new regulation was advised for this bay. The calculated long-term losses to the fishery are marginal at less than 4% in the first year with recovery of this loss by the fourth year after implementation of the new regulation. After 5 years the long-term gain to the haddock fishery is in the order of 1% per annum depending on stock structure. The economic impacts coincide with the above trends in yield with vessels in the St. Mary's Bay losing the most if the 130 mm codend regulation was imposed.

RÉSUMÉ

Waldron, D.E., T.D. Iles, and G.V. Hurley. 1985. Estimating the Effects of Introducing a Minimum 130 mm Mesh Regulation on the 4X Groundfish Fishery. Can. Tech. Rep. Fish. Aquat. Sci. No. 1400.

Au printemps 1982, on a entrepris d'étudier la réglementation du ministère des Pêches et Océans concernant l'uniformisation de la grandeur des mailles des chaluts à panneaux dans la zone économique canadienne. On a organisé un programme d'observation pour recueillir des données sur la grandeur des mailles des chaluts actuellement employés et sur les conséquences qu'aurait l'augmentation de cette dimension pour l'industrie du sud-ouest de la Nouvelle-Ecosse, région qui serait la plus touchée par un tel changement selon le ministère. On a constaté que pour 50% des bateaux de l'échantillon la grandeur des mailles des chaluts employés est très proche de 130 mm, la dimension proposée. D'après les calculs effectués, la baisse immédiate des prises d'aiglefin dans la pêche se répartirait en proportions inégales entre les diverses flottes étudiées. La grandeur des mailles de la poche des chaluts employés sur les petits bateaux de la baie Ste-Marie est inférieure à 120 mm, la dimension réglementaire actuelle. Si les mailles de ces poches de chaluts mesuraient 130 mm, les prises d'aiglefin de ces bateaux pourraient baisser de 70% et leurs captures principales, constituées de plie, diminueraient dans une proportion considérable. On recommande d'exclure cette baie de la nouvelle réglementation. D'après les calculs, les pertes à long terme dans la pêche seraient marginales : elles seraient inférieures à 4% la première année de l'application de la nouvelle réglementation et seraient compensées avant la cinquième année. Au bout de cinq ans, le gain à long terme serait de l'ordre de 1% par années dans la pêche, tout dépendant de la structure du stock. Les conséquences économiques sont à l'avenant des tendances du rendement décrites ci-haut; les bateaux de la baie Ste-Marie essuieraient les plus fortes pertes si la grandeur réglementaire des mailles de la poche des chaluts était fixée à 130 mm.

Introduction

On January 1, 1982, the Canadian Department of Fisheries and Oceans (DFO) introduced a new regulation governing the mesh size of otter trawl codends used in the Northwest Atlantic Fisheries Organization (NAFO) Subareas 4 and 5. It stated that the codend mesh size should be no smaller than 130 mm irrespective of material. This represents a change from the previous regulation which specified mesh sizes greater than or equal to 120 mm depending on material.

Fishermen's groups in Southwest Nova Scotia protested this change in the regulation and asked that it not be made before a study of its impact on their haddock fishery was conducted. The Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) was commissioned for advice. Its findings summarized by O'Boyle et al. (1981) indicated that the short-term effect of a change in mesh regulation would be a reduction in haddock catch rates, primarily by reducing catches of two and three year old fish. Inshore otter trawlers operating in NAFO Subdivision 4Xr which catch predominately age two and three haddock stood to experience decreases of catch rates up to 50%. Landings by this fleet component are small (12% of total 4X landings in 1980) and as such long-term yield changes to the fishery as a whole were predicted to be small. It became evident that the immediate impact was going to be greater on the fishermen than on the haddock stock.

The above analysis was, of course, conditional on the validity of some of the over-riding assumptions, the main among these being the number of vessels presently using 120 mm mesh codends. As well, yield projections were carried out using historical commercial sampling data which had only minimal information on the age structure of fish caught by the smaller inshore trawlers. Before new advice could be given, more field data was required to offset these deficiencies.

This study assesses the impact of a mesh size change particularly on the 4X haddock small otter trawler fishery in four ways.

First, the impact on the stock. Attention here is focused on the short and long-term effects on stock biomass and whether or not recruitment to age groups older than age 4 would be seriously affected.

Second, the impact of the proposed regulation on the industry. The overall change in yield to the fishery, both in the short (next three years) and the long (steady state) terms were studied. The analysis used changes in the selectivity of the gear for the short-term scenario and yield-per-recruit and projections based on the 1981 population structure for the long-term view.

Third, the issue of the new regulation's economic impact on the fishermen and processors of the regulation. It is assumed that fishermen would be most dramatically affected by short-term changes in the catch rates as a result of an increase in mesh size. Impact to the processors is studied by examining how plants react to changes in size of the fish and the amount of fish landed.

Fourth, the enforceability of the new regulation. Creation of any regulation is only as good as its ability to be perceived as worthy of being obeyed as well as the ability of governments to enforce it.

Materials and Methods

Observer Deployment

In the spring of 1982 haddock fishermen using small otter trawlers from Southwest Nova Scotia requested that this study be conducted. Following government and industry meetings the Regional Director General of DFO Scotia-Fundy Region defined the fleet to be studied as those vessels fishing from ports in that part of 4X defined by DFO Statistical Areas 32 and 38 (Figure 1). The study was to employ the resources of the Fisheries Research and Economics Branches.

To design the sampling program and then to evaluate the potential impacts of the new regulation, time series of data were required which covered a range of conditions, both biological and economic. Three historical data sets were used to assist in these analyses. The first is the Maritime catch and effort statistics for 1967 to 1982 (O'Boyle et al. 1981). These data were examined for seasonal and annual trends in haddock catches by various sized vessels and for the dependence of communities on various fishing areas in 4X.

The otter trawler fleet can be divided into groups based upon length overall (LOA) and tonnage class (TC). There is a loose correlation between these two terms. These definitions generally apply: tonnage class 1 (0-24.9 Gross Registered Tonnes or GRT) vessels are less than 40' LOA; TC 2 (25-49.9 GRT) vessels are between 41' and 44'11" LOA; TC 3 (50-149.9 GRT) vessels are between 45' and 64'11" LOA; TC 4 (150-249.9 GRT) vessels are between 65' and 124' LOA and TC 5 (250-499.9 GRT) vessels are greater than 124' LOA (Table 1). Nominal landings are reported to NAFO by TC and are subsequently used in the DFO stock assessment process. To be consistant with these analyses, this analysis of the 4X area will use the TC rather than LOA designation. This may create some confusion especially, as most regulations as well as the DFO management plans, use LOA.

Small otter trawlers (less than 40' in length and 25 tonnes) are not required to maintain daily logs of their fishing activities and as a result little is known of their fishing activities. In general, for the purpose of interpreting their landings by port it was assumed that these vessels usually conduct day trips and therefore fish in areas close to their home ports. Landings reported by each port for TC 1 vessels would be indicative of fish caught in proximity to that port.

The second data set was commercial length and age samples collected by port technicians of the Canadian Department of Fisheries and Oceans in the Scotia-Fundy Region for the period 1967 to 1982. One concern expressed by the industry and departmental biologists was that the small mesh gear was removing recruiting year classes. Areas having large concentrations of small haddock were identified from the samples. It was not possible to sample all areas adequately using the port sampling program due to the diversity of the fishery and the number and distribution of the vessels engaged in the haddock fishery. These port samples were augmented with observations taken at sea during the 1978 to 1982 International Observer Program (IOP) in order to see if there were other areas where small haddock aggregate.

Third, distribution and the structure of the fleet was analysed using information from the Department of Fisheries and Oceans Scotia-Fundy domestic licensing system. These data were used to isolate sectors of the otter trawl fishery which needed further study due to their complexity. Four primary areas were identified: the Cape Sable Island area because of the large concentration of fishing vessels which were hypothesized to fish on Browns and Georges Banks; the Meteghan area as this was the base for many of the larger tonnage class 2 (TC 2) vessels which were reported to be the most seriously affected by any change in the existing mesh regulation; the St. Mary's Bay area because of the presence of small haddock in the commercial samples which had led to the speculation about the presence of a haddock juvenile rearing area in the Bay; and finally, the Digby area which gave some coverage of the Bay of Fundy groundfish fishery.

Deployment of observers commenced in April, 1982 and was restricted to vessels within the mandate of this special study. These vessels were otter trawlers less than 65 feet in length overall (LOA) which put them in Tonnage Classes 1 to 3. Larger vessels were generally found in ports outside of the study area and therefore were not sampled. In the Digby area there are several larger TC 3 draggers which are licensed to fish either scallops or groundfish. Since these particular vessels revert to scallop fishing during the summer months they were not part of the sampling program.

A project manager was delegated the responsibility to establish and maintain this study. He assigned an observer permanently to one of the 4 areas defined above. Attempts were made to rotate the observers through the TC 1-3 otter trawler fleet. This met with varied success. The isolation of certain communities often hampered the observers ability to rendezvous with the fleet. Many of the smallest vessels (TC 1) were not sampled for this reason. Often the vessel selected was the only one in port at the time, the remainder being at sea.

Observers were instructed to partition their efforts on a tonnage class basis giving the most time to the vessel class with the major percentage of vessels in their area.

At Sea Sampling Protocol

Observers were instructed to collect data on the area, depth, time of day, the amount of time fished and the quantity by species caught. Haddock length measurements were taken from most sets and if time permitted one or more of the other commercial species caught were also sampled for lengths. Onboard observer sampling protocols are described in Kulka and Waldron (1983).

During the initiation of this study there was some speculation that certain types of codends would not maintain their mesh size during prolonged usage. While on board each vessel, the observers interviewed the captain and completed a gear questionnaire. They collected information on the size of the codend mesh that the captain thought he was using, the age of the codend, and the supplier who sold him the codend. Occasionally the information could not be obtained for example, when the captain of the vessel was not the owner and therefore had not purchased the codend, or when he had more than one codend aboard the vessel from several possible sources. A few captains made a special effort after the trip to obtain this information for the observer and generally were quite cooperative during the study.

Where possible, observers measured each codend using the DFO standard NAFO gauge with a 5 kilogram weight attached. On most trips measurements were taken three times: dry (before fishing), wet (mid trip), and wet (immediately after the last set). Each time twenty consecutive meshes were measured at least ten meshes away from the seam.

Surveys of the Fishing Industry

O'Boyle et al. (1981) suggested that field studies should be conducted in order to better determine the impact of the new regulation on all sectors of the fishing industry. In 1982 several surveys in addition to the observer program operations were conducted. These were directed at both fishermen, processors, gear manufacturers and government fisheries officers.

Mail Survey to Fishermen

There was little information on the codend mesh sizes being used in the otter trawl fishery. In order to ascertain the breadth of the impact of the proposed mesh increase a questionnaire was mailed to fishermen asking what range of codend mesh were currently in use. A self-stamped return addressed post card was distributed to all licensed fishermen in 4X (Figure 2). This was done to ensure that fishermen owning vessels registered in the study area but living in communities outside of this area were contacted. Data was requested on the vessels fished, whether the fisherman was active in the fishery during the past year, the codend mesh sizes used and where it was purchased. Realizing that fishermen would probably report that they used nets within the current mesh regulations, the questionnaire gave 2 options -- 120 mm or 130 mm.

The answers to these questions would help establish the percentage of actively fishing vessels and give us some idea of the type of nets being employed in the fishery.

Interviews

To collect more data on the economics of fishing operations in 4X we initiated interviews of fishermen, processors and departmental fisheries officers (Appendix A). These interviews gave information on the vessel and gear characteristics, fishing patterns, on-board processing activities and haddock population characteristics. Particular emphasis was placed on the impact of the regulation change on the fisherman's operating costs and fishing patterns.

In most cases fishermen interviews were done onshore when the fisherman was less distracted. Processors were interviewed to evaluate their response to a change in the supply of and size of haddock landed. Attention was paid to quality, product yields and price differentials for haddock of various sizes. Due to time constraints these interviews were conducted by the project manager who subsampled a cross-section of fresh, salt fish, and frozen fish processors.

Processors in the Digby area were sampled the most. It was rumoured that these plants relied on processing of small haddock; in fact some of these plants routinely processed fish under 17" (43 cm). These plants would be the first to suffer since landings of the fish under 17" would be most reduced if the proposed mesh regulation was enacted.

The last set of interviews was with DFO Fishery Officers stationed in the study area. Emphasis in this interview was placed on obtaining information on fishermen activites in 4X, potential enforcement problems which would arise from imposition of the new regulation and the perceived status of the haddock resource. The DFO area offices in Digby and Yarmouth selected 12 of its most experienced officers to be interviewed.

Evaluating Short and Long-Term Impacts

Although this study was primarily directed towards haddock, other commercial species, such as cod, pollock, and winter flounder, could not be ignored as certain areas relied on these species. It required little extra effort in data collection and was accomplished under the sampling protocols of the IOP. These data provided us with the ability to evaluate the immediate impact of increased codend mesh size on the overall otter trawl groundfish fishery in southwestern Nova Scotia.

Two models were used in these analyses. The first described the loss in yield due simply to a shift in the selectivity of the gear. This we call the Direct Method. The second model used modifications in selectivity to alter the fishing. This later model, referred to as the Indirect Method or Yield-Per-Recruit (Y/R), is a convenient tool to investigate possible shifts in population structure and any resultant changes in yield to the fishery.

Direct Method

The short-term loss in yield of haddock was calculated by assuming that observed codends below a mesh size of 130 mm were replaced by 130 mm. To accomplish this, an appropriate pattern of selection at fish length was adjusted by means of the 50% retention lengths corresponding to the observed codend mesh sizes. The selection ogives at the observed mesh size and at 130 mm were each applied to the length-frequency distribution on a tow by tow basis and the percent loss in yield calculated.

The shape of the selection ogive was approximated by fitting a logistic curve (O'Boyle 1981) to the data provided by Clark et al. (1958) on selection at length for haddock caught in 127 mm codends. Similarly, selectivity ogives for cod (Hodder 1964), winter flounder (Metuzals 1981), and pollock (Clay 1979) were used. These selectivity ogives were adjusted to the observed and proposed 130 mm mesh using the appropriate 50% retention lengths from Clay (1979).

Indirect Method (Yield/Recruit)

Partial recruitment patterns for TC 1-3 otter trawlers using codends with mesh less than 130 mm were calculated after O'Boyle et al (1981). The equations below were solved for the 1981 age structure reported in the most recent assessment (O'Boyle and White 1982). Fishing mortality (F1) for TC 1-3 otter trawlers was calculated by the following equations:

$$F1 = (C1 \times Ftot)/Ctot \qquad (1)$$

Where: Ctot = total catch-at-age in 1981, from O'Boyle and White 1982;
Ftot = total fishing mortality(F)-at-age in 1981, from O'Boyle and White 1982;
C1 = catch-at-age for otter trawlers, TC 1-3 fishing in 4X during 1981 (current study shows average mesh size used by TC 1-3 is 122 mm), data from O'Boyle and White 1982; and
F1 = fishing mortality(F)-at-age for TC 1-3 otter trawlers fishing in 4X during 1981.

The fishing mortality (F2) for all other vessels and gear components is calculated using the following formula:

$$F2 = Ftot \times (Ctot - C1)/Ctot \qquad (2)$$

Length selection curves for 122 mm (S122) and 130 mm (S130) gear were derived from Clay (1979). Selection-at-age was calculated from the 1981 removals-at-length (provided by O'Boyle and White 1982) and the selection-at-length curve (Clay 1979) for each age. A new partial recruitment pattern (PRnew) was calculated using the following equations:

$$F1,130 = S130 / S122 \times F1 \quad (3)$$

and

$$Ftot,130 = F1,130 + F2 \quad (4)$$

A Thompson and Bell Y/R model (Ricker 1975) and 10 year projections (using the MPROJECT function of Rivard 1982) were calculated using the weights, catch and population numbers and partial recruitments-at-age (O'Boyle and White 1982) and the new partial recruitment calculated above in equations 3 and 4.

The 1981 haddock fishery was supported by the moderately large 1975 and 1977 year classes (O'Boyle and White 1982). The large 1979 year class should have its major impact on the fishery in 1983. It appears that the 1980 year class is also as large as the 1979 year class. Constant recruitment used in this model was that recommended by O'Boyle and White (1982) at 40 million fish per year. If the 1980 year class is as large as indicated by O'Boyle then any impacts of imposing a codend mesh increase would be decreased in the projections.

Minimum Size Landed

Adoption of the USA minimum landed size for haddock (17", age 4) was considered as a possible option to imposing a universal mesh increase in the study area. The above long-term projections were used to determine what amount of discarding could occur. All fish below age 4 (17") were assumed to be eligible for discarding. Recruitment was again held at 40 million fish per year.

Results

Historical Fleet Profile

Based on log books, the number of TC 2-5 otter trawlers fishing haddock in 4X has remained relatively stable at an average of 194 during the 11 year period 1968-1978 (Table 2). This number increased by about 13% per year from 1979-1981. Most of this increase was in the number of TC 2 vessels which have increased by 59% since 1968. Much of that increase in the number of TC 2 vessels occurred since 1978. The trends in the number of TC 3 and TC 2 vessels are different. The TC 3 vessels averaged 51 during 1968-1971. This subsequently dropped to 39 from 1972-1978 and then rose to 62 by 1981. The number of active TC 4 vessels fluctuated since 1968, now there are 25. Tonnage class 5 have steadily increased from an average of 18 for the period 1968-1974 to an average of 30 vessels during 1975-1981, a 67% increase in 7 years.

The number of vessels licensed in the study area (districts 32-38) during 1981-1982 are broken down by TC and presented in Table 3. Tonnage class 1 vessels represent 53% of all vessels in the study area. About 27% of the licensed vessels in the fleet were TC 2; 68% of these were less than 45' LOA (Table 1). Tonnage class 3 vessels represent 21% of those vessels licensed in the study area. Most of these TC 3 vessels were between 45' and 64'11". There are 3 TC 4 vessels registered in the study area all of which are in Statistical District 32 (Cape Sable Island area). These vessels were between 100' and 125' LOA.

Tonnage class 1 and 2 vessels are evenly distributed between those fishing north and south of St. Mary's Bay. Tonnage class 3 vessels are concentrated in the Digby and Digby Neck areas (Districts 37 and 38).

Historical 4X Haddock Fishery

Haddock in NAFO Division 4X are fished mainly by Canadian vessels (Table 4). Otter trawlers account for the major part of the landings (Table 5 and Figure 3). Landings by the Maritime fleet in 1981 for this fishery approached the record 1967 catch of 33,000 tons. Historically the major haddock catches have been by TC 4 and TC 5 vessels (Table 6 and Figure 4). Since implementation of DFO quota management plans in 1977 TC 1-3 vessels have reported the major catch. Between 1970 and 1977 both TC 1-3 and TC 4-5 vessels shared this resource equally.

The spatial distribution of historical catches are presented in Table 7. The TC 1-3 group of vessels (inshore fleet) were concentrated in NAFO areas 4Xn-r with peak reported catches in the 4Xn and 4Xq-r areas. The TC 4-5 group of vessels (offshore fleet) fish primarily the 4Xn and 4Xo areas. These larger vessels do not fish the 4Xr area and report modest catches from 4Xq.

In 1981, the provisional catch of 4X haddock was 30,000 tonnes of which 14,600 tonnes (or 47%) were reported by inshore fleet (Tables 5 and 7). Of this, 3,278 tonnes (22% of inshore or 11% of total) was caught in NAFO Unit Areas 4Xr. The historical 4Xr catch by the inshore fleet has ranged between 10 and 15% of the total catch. From 1968 to 1976 catches by inshore vessels were the largest in 4Xr. Since then, other areas reported as much catch, if not more, than those reported for the 4Xr area. Now 4Xq and 4Xn catches contribute as much to the total catch as the 4Xr fishery.

Nearly half of the stock's yield during 1970-1981 went to the offshore otter trawler fleet operating in areas other than 4Xr.

Observer Deployment

A total of 64 vessels of tonnage classes 1 to 3 were observed during the program (Table 8). Eighty-eight trips were observed between the months of May and September inclusive. Twenty percent of the 316 licensed otter trawlers in Statistical Districts 32-38 were sampled. Tonnage class 1 vessels were least sampled (17%) because of difficulties in deploying observers. Tonnage classes 2 and 3 vessels were observed at a rate of 33% and 29% respectively.

In total, the 628 observed sets were uniformly distributed over the five months which

the program operated. Observed sets ranged from Browns Bank to the Bay of Fundy and on Georges Bank (Figure 5). Sets were clustered in the St. Mary's Bay, Lurcher and Trinity Ledges along the 50 m contour and up the Fundian Channel.

There was minimal coverage of TC 1 vessels in Statistical Districts 32-34. Observed TC 1 vessels from this area fished Trinity Ledge and Georges Bank (Figure 6). The highest observer coverage of the TC 1 vessels was in the St. Mary's Bay area during the months of August and September. Tonnage class 1 vessels from Statistical Districts 36-38 were observed to fish in the St. Mary's Bay, Trinity Ledge and in the Bay of Fundy (Figure 7). On a set by set basis, coverage of TC 1 vessels in other areas ranged from 2-8%.

Catch Distribution

A) HADDOCK (MELANOGRAMMUS AEGLEFINUS L.)

The 147 tonnes of haddock observed represented 1.3% of the total reported 4X catch as of September 31, 1982. The major haddock fishery observed for TC 1 vessels was inside, and adjacent to St. Mary's Bay, the Bay of Fundy and Georges Bank (Figure 10 and Table 9). It was interesting to note that vessels from Statistical Districts 32-34 (Cape Sable Island to Yarmouth) fished areas at some distance from their home ports (Figure 6). In contrast, TC 1 vessels from Districts 36-38 (Meteghan to Digby) fished for haddock in close proximity to their home ports (Figure 7).

Haddock catches by TC 2 vessels were more widely distributed reflecting the mobility of these vessels (Figure 8). Of particular interest is the clustering of catches along Digby Neck and in St. Mary's Bay. Haddock catches by TC 3 vessels were observed in the deeper waters of the Fundian Channel (Figure 9).

Throughout the study the areas off Lurcher Shoal, Trinity Ledge and the Digby Neck areas were very important for haddock catches.

B) COD (GADUS MORHUA L.)

As of mid October 1982, 6,900 tonnes of cod was reported caught by otter trawlers in 4X which was an increase over the same time period in 1981 (Table 10). Tonnage classes 1-3 vessels accounted for 80% of the reported catch with the majority being caught by TC 2 and 3. During this study, cod was observed most often (251 t) (Table 9). That is 5% of the reported 1982 catch for TC 1-3 vessels.

The largest observed catches of cod were from Georges Bank (NAFO Unit Area 5Zj) with the next largest from the 4Xr area. Little cod was caught on observed TC 1 vessels. The distribution of cod catches for TC 1 and primarily TC 2 vessels occurred along the 50 meter contours of the Fundian Channel, Lurcher Shoal and Georges Bank (Figure 11). Tonnage class 3 vessels were observed to have similar fishing patterns for cod as those seen for TC 2 vessels (Figure 12). However, there is more fishing by these vessels in deeper waters than either of the other two vessel classes.

C) POLLOCK (POLLACHIUS VIRENS L.)

The January-September 1982 4X pollock fishery for TC 1-3 otter trawlers increased by 53% over the same time period in 1981 (Table 10). At the end of September, 1982, 73 tonnes of pollock or 2% of the reported landings by otter trawlers were observed in the 4X area (Table 9). The largest observed catches of pollock were for TC 2 and TC 3 vessels fishing in the 4Xr and 4Xq areas (37% and 38% of the total observed catch respectively).

Pollock, like cod, are caught mainly between the 50 and 100 meter contours. The densest aggregations of TC 2 vessel catches are in the Bay of Fundy along the 50 m contour adjacent to Digby Neck (Figure 13). The observed pollock catch for TC 3 vessels is similar but reflects the wider fishing range of these vessels with their ability to fish deeper (Figure 14).

D) WINTER FLOUNDER (PSEUDOPLEURONECTES AMERICANUS W.)

Reported landings of 4X winter flounder for January-September increased 45% in 1982 over the same period in 1981 (Table 10). Ninety-nine percent of the 1982 winter flounder landings were reported by TC 1 vessels. Accurate data on winter flounder removals are frustrated by plants which do not differentiate the purchase price for the various flatfish species landed.

This study observed 3% of the reported landings for TC 1-3 otter trawlers. Winter flounder is seldom observed as the main species sought or caught in the fishery studied. One exception to this observation are those vessels (TC 1) fishing inside St. Mary's Bay where winter flounder is a most important species (Table 9 and Figure 15). Other areas fished by TC 1 and TC 2 are clustered along the 50 meter contours of Lurcher Shoal and Browns Bank (Figure 16). Tonnage class 3 vessels also caught winter flounder in these areas (Figure 17).

Sampling for Length-Frequencies

Throughout this study haddock length sampling was given the highest priority and by the end of the study 199 haddock samples were taken (Table 11). In addition to minimal catches of haddock, length sampling on TC 1 vessels presented logistical problems in locating space to measure the fish. The distribution of the 94 cod samples among the studied vessels was similar to those of haddock. The 29 pollock and 32 winter flounder samples were mostly from vessels in the Meteghan and Digby areas.

Size of Haddock in the 4X Fishery

Sampling of haddock landings has been conducted since 1948 by the Fisheries Resource Branch (FRB) of DFO Scotia-Fundy Region. From these samples it could be seen that small haddock are most abundant in 4Xr (Figure 18). The modal length of haddock sampled in 4Xr is 36 cm (14")

which equates to fish of age 2. Fish sampled from 4Xq have a modal length of 45 cm (18", age 3) while haddock sampled from the other areas have a modal length of 50 cm (20", age 4).

Samples collected in 1982 during the FRB's commercial sampling program demonstrate that in 4Xr more age 2 (36 cm) fish are caught than in any other area (Figure 19). The peak at 42 cm (age 3) is the large 1979 year class which creates the impression that the historical pattern for 4X in Figure 18 has changed for 1982.

Haddock of lengths 29-43 cm (ages 2-4) dominated catches of TC 1 vessels fishing 4Xr (Figure 20). In particular the percentage of age 2 fish caught by these vessels is the largest of all tonnage classes sampled. Age 2 haddock are distributed throughout the study area (Figure 21). Haddock older than age 4 are not present in samples taken from vessels fishing inside St. Mary's Bay (Figure 22).

Mesh Size Surveys

A) MAIL SURVEY

A mail survey was distributed to all the owners of vessels who had a groundfish mobile license in the 4X area (432). The return rate was 34% (146) (Table 12). Coverage was reasonably good in all areas within 4X particularly in the St. Mary's Bay and Digby areas (Districts 37 and 38). This was fortuitous since the fleet base in the town of Digby was poorly covered by the IOP.

Codend mesh sizes by vessel tonnage class from the mail survey are presented in Table 13. It was assumed that vessel owners using less than 120 mm codends indicated they were using 120 mm since no fisherman would admit to using a codend mesh size less than that allowed by the regulations. Reponses by TC 1-3 were evenly distributed throughout the surveyed area. From this study it appeared that all vessel sizes in the 4X otter trawler fleet used 120 mm and 130 mm equally. Most vessels in the Meteghan to Digby area preferred the smaller mesh. Thirty-five percent of the vessels licensed in the area from Halifax to Shelburne use codends with meshes 120 mm.

Interestingly, 12% of the returns indicated that they had not actively fished for groundfish in the last 12 months.

B) FISHERMEN INTERVIEWS

Coverage of the fishermen in the interview survey ranged from 7% in the Cape Sable Island to 43% in the Yarmouth areas with an overall 17% for the study area (Table 14). Again, fishermen were not asked to specify if they used codend meshes less than the regulated limit of 120 mm.

Overall, 60% of the TC 1-2 vessel owners reported using 120 mm mesh whereas 73% of the TC 3 vessel owners used 130 mm (Table 15). Most fishermen owning smaller vessels (TC 1-2) in the Districts 36-38 (Meteghan to Digby) used 120 mm. In contrast fishermen operating TC 1-2 vessels in Districts 32 to 34 (Cape Sable Island to Yarmouth) used both meshes equally. Large vessels, TC 3, based in the area from Cape Sable Island to Yarmouth use 130 mm mesh while the same size vessels based in Meteghan to Digby used both meshes equally.

C) OBSERVED MESH SIZE

Mesh information was collected from 64 different TC 1-3 vessels based in Districts 32-38 (Table 16). The observer results are similar to those from the mail survey and fishermen interviews. Tonnage class 1-2 vessels based in the Meteghan to Digby area use less than and greater than 130 mm about equally.

The observer data set is the only information available on vessels using less than 120 mm mesh. Seventy-six percent of TC 1 vessels, mostly from the Meteghan to Digby area, use codends less than 120 mm. All observed TC 1 vessels from Districts 37-38 use meshes less than 120 mm. Only 29% of the vessels sampled used nets with codend meshes greater than or equal to 130 mm.

Observer measurements reveal that the average mesh used by TC 1s from Meteghan to Digby were less than 116 mm (Table 17). These mesh measurements give evidence to support O'Boyle's (1981) earlier hypothesis about the small size of codend meshes used in this fishery.

D) FISHERIES OFFICER OBSERVATIONS ON MESH SIZES

The 12 officers interviewed collectively represented 170 years of experience in the study area (Table 18). Most of the officers were from the Meteghan to Digby area and indicated that the codend mesh used by vessels within their area of responsibility ranged from as little as 90 mm to 130 mm. Other comments were intriguing and would be of benefit in developing an enforcement policy. Sixty-seven percent of the officers agree with a universal minimum mesh size. Twenty-five percent agreed with a universal minimum of 130 mm. A further 25% of the officers said no to any universal minimum mesh citing the 4Xr region as the exception.

E) MESH SIZE TOLERANCE

During the mesh size surveys tolerance limits were discussed (Tables 17 and 18). There are two different prestretched net manufacturing methods employed in the construction of codends. These are classified as heat-set, an imported mesh material, and non-heat-set, a locally produced material. The difference is that the knots are immovable after the heat-set process whereas the knots of the non-heat set codends are loose and can easily slip. The degree to which these two processes influence the net measurements made are described below.

Both heat-set and non-heat-set codends were stratified into three "sold as" categories namely less than 120 mm, 120 mm and 130mm (Table 19). Information was available for a total of 56 different vessels. In most cases mean mesh sizes

for both heat-set and non-heat-set codends were greater than the 120 mm and 130 mm "sold as" due to knot slippage and fiber stretching.

Heat-set codends "sold as" less than 120 mm and 120 mm maintained their original size after use much better than the non-heat-set codends (Table 19). For example the mean mesh size of non-heat-set codends "sold as" 120 mm was 129 mm compared to 122 mm for heat-set codends. Similarly for codends sold as 130 mm the non-heat-set codends average mean mesh size (138 mm) was much greater than that of the heat-set codends (129 mm).

It was dificult to determine the exact sizes which the less than 120 mm codends were "sold as". Many of these codends were handmade by fishermen, others were manufactured for fishing flounders or redfish for which there are no minimum codend mesh size regulations. The knots on new undersized non-heat-set codends appeared to be much tighter than on the larger mesh nets. This was due to the smaller diameter twine which could be prestretched more effectively.

Table 20 gives the mean difference between the dry and wet mesh measurements along with the standard deviation and the number of vessels sampled with heat-set and non-heat-set codends by mesh size category. The difference in each category irrespective of manufacturing treatment was less than 1 mm. The less-than-120 mm non-heat-set codends generally behaved similar to all sizes of heat-set codends showing some stretching from dry to wet. In contrast, there was some shrinkage from dry to wet with the non-heat-set codends sold as 120 mm and 130 mm. It is difficult to draw firm conclusions from the above data due to the magnitude of the sampling variation around the mean differences.

Observer codend mean wet measurements by age and mesh size categories for heat-set and non-heat-set codends are summarized in Table 21. Heat-set codends, 120 mm and greater generally retained their size better than non-heat set nets.

Fisheries officers gave their opinions on whether there should be any mesh tolerance given to the 130 mm regulation (Table 18). Fifty percent stated there should be no tolerance while 25% indicated there should be tolerance limits from 2% to 10%. Twenty-five percent did not answer the question.

Short-Term Losses to the Fishery (Direct Method)

A) HADDOCK

Tonnage class 1 vessels can lose 27% of their haddock catch using the direct method to calculate short-term loss (Table 22). The St. Mary's Bay-Digby area will lose the most (74%). In most cases these vessels use codend mesh less than 120 mm. The TC 2 and TC 3 fleets could lose 13% and 8% of their haddock catch respectively. These vessels use mesh sizes larger than 120 mm.

B) COD

The loss in cod catch due to a proposed increase in codend mesh is highly variable (Table 22). Sampling for lengths on tonnage class 2 vessels fishing in Statistical District 32 was large enough (814 lengths) to calculate the loss in yield by increasing the mesh size. The loss in yield of cod for these vessels was calculated to be 55%. Conversely TC 2 vessels fishing from Statistical District 37 had 871 cod lengths taken and the calculated loss in yield was only 8%. The occurrance of TC 3 vessels carrying less than 130 mm and having been sampled for cod lengths was minimal. The ability to calculate losses in cod catch was therefore limited to only a few vessels from Statistical Districts 37-38. The calculated losses for these vessels was 13%. Since the yield calculations are dependant upon the change from the observed to the 130 mm size, the average mesh size being 119 mm on a few vessels would have caused this loss in yield. On average, the mesh size observed for the TC 3 fleet was 125 mm (Table 17).

C) POLLOCK

The loss in yield for pollock is the least for all the species studied. As stated above, few pollock were caught on TC 1 vessels, and no loss in pollock catch can be calculated. For other vessels the catch losses ranged from less than .1 to 7% (Table 22). It was highest for TC 2 vessels using 124 mm codends fishing 4Xr (7%). Tonnage class 3 vessels from District 33 experienced a decrease in yield of 1.4% while fishing 4Xq-r.

D) WINTER FLOUNDER

Short-term reductions in winter flounder catches are substantial, about 30%, in the main fishing area of 4Xr (Table 22). Since both TC 1 and TC 2 vessels incur similar losses while using varying mesh sizes such losses must be related to the fish size.

Long Term Yields of Haddock

A new partial recruitment pattern was calculated reflecting a change in mesh size from the observed average of 122 mm to the proposed 130 mm are presented in Table 23. The change in partial recruitment-at-age for ages 1 to 2 are greatly reduced. Partial recruitment for ages 3 to the new age of full recruitment-at-age (8) are not greatly changed from those calculated previously.

A Thompson and Bell yield-per-recruit analysis using the parameters shown in Table 24 gave a 3% change in the $F_{0.1}$ fishing mortality from 0.271 to 0.278 (Table 25). An increase in effort of 6% would be required to fishses at F_{max} (0.561 to 0.595). Since these increa in effort were calculated by increasing the selectivity of one component of the total fishery then it is that component which will suffer the increase. The yield-per-recruit changes by 1% from .603 to .608 kg.

Recruitment was held constant at the historical average of 40 million fish-per-year while the $F_{0.1}$ was varied from .271 to .278. As expected there is a computed loss in yield, to the total 4X haddock fishery, of 3.7%, 2.6%, and .5% for each of the first 3 years after imposition of the new regulation. By the 4th year there is some net gain to the fishery with an expected long-term increase to the total fishery of 1% per year (Figure 22). The accumulated losses in catch will be regained after 9 years (Figure 21).

Economic Effects

Economic effects can only be given a cursory approach because of a lack of data available to analyze such a broad subject. This study attempted to evaluate loss in revenue to various tonnage classes of otter trawlers. These results are elaborated in the economic report (Appendix A).

Short-term losses in revenues from the 4X haddock fishery can be approximated using the assumption that the vessels will restrict their fishing effort and area fished to those observed during the study. Looking only at changes in gross revenues, the TC 1-3 otter trawler fleet would experience losses in direct relationship to the projected loss in catch times the average landed value of one ton of haddock in 1981 ($433.00/t) (fish prices review). Tonnage class 2 vessels would lose the most ($390,000) and TC 1 and TC 3 would lose about equal amounts ($240,000 and $250,000)(Table 27).

The long-term losses are also equated to the loss in catch as projected above. Again, assuming vessels will not alter their fishing patterns nor haddock change their distributional patterns, the losses for each year after imposition are not as severe as those calculated from the short-term model. Assuming the 1981 price-per-ton of haddock was $433, the loss in the first three years by the total 4X fishery are $399,934; $336,008; and $71,445 respectively.

Special Considerations

A) ST. MARY'S BAY

Vessels fishing in St. Mary's Bay will be most adversely affected by the proposed mesh increase. These vessels are heavily dependant upon winter flounder resident to the bay (Figure 23 and Table 9). Losses will be experienced by reductions in haddock (14-74%) and winter flounder (30-36%) catches (Table 22). Haddock older than age 4 were not observed in the bay (Figures 21 and 22). Fisheries officers corroborated the above observations of small haddock in the bay (Table 18) which suggests that unless these vessels move outside of the bay they will never recoup their losses.

Observations made by this study suggest that all of the winter flounder catches by St. Mary's Bay vessels are made within the bay (Figure 15). Haddock catches were observed by these vessels to occur both inside and outside the bay indicating that these vessels have a degree of mobility (Figure 24).

Short-term losses would be reduced if the proposed mesh increase was to 120 mm rather than 130 mm (Table 28). The calculated loss in cod and haddock would be reduced by 50%. Calculated losses in the winter flounder catches could be reduced by 70%.

B) MINIMUM LANDED SIZE OF HADDOCK

The USA has recently imposed a 17" (43 cm) minimum landed size for haddock. This was considered by some processors, who sell fresh fish on the Boston market, and by DFO officials as a means to avoid the imposition of a mesh size increase (Table 18). The model used indicated that there would be a substantial quantity of discards (Table 29). Assuming no mesh increase, the imposition of a minimum landed size would result in a discard rate of 35%. Increasing the mesh size to 130 mm would reduce this discard rate to 28%. Concomitantly the effort would increase by 35 to 28% depending upon the scenario considered.

The imposition of a minimum landed size for haddock would also imply a decrease in the present TAC of 32,000 t. If not, the actual catch would be the old TAC plus the discards putting it well above the $F_{0.1}$ level.

C) OTHER MANAGEMENT ISSUES

The fishery officers interviews provided other options related to management issues in the 4X area (Table 18). One officer suggested that the minimum mesh size be imposed at the manufacturing level so a fisherman would not unknowingly purchase a net below the regulated mesh size.

For the past several years there has been a policy to restrict vessels greater than 40' registered length (a Canadian Ministry of Transport measure) from fishing in St. Mary's Bay, as defined by a line from the tip of Cape St. Mary's to the tip of Brier Island. There is a current proposal to create a regulation which would permit fishing in the bay for those vessels which are less than 40' registered length and less than 45' LOA. Such a change would restrict three vessels which currently fish the bay.

When interviewed, several small vessel owners based near the head of St. Mary's Bay are in favour of further restricting access to fishing in the bay to those vessels less that 250 brake horsepower. This would eliminate TC 2 and 3 vessels from the bay.

Discussion

Two methods have been applied to determine the impact of an increase in the codend mesh size used by otter trawlers in the south-western part of Nova Scotia. The direct method gives short-term immediate results and the yield-per-recruit (indirect) method gives additional information on the long-term impact to the total fishery.

The direct method of assessment and analysis indicates a larger immediate effect almost doubling the immediate loss for haddock with correspondingly greater immediate effects on the inshore components. In most instances these losses could probably be offset by adjustments of fishing patterns. Areas that offer better catch rates for haddock are available for TC 2 and TC 3 and some TC 1 boats operating in those areas most affected by the mesh increase. Whether these vessels would or could change their traditional fishing grounds is debatable. In addition there is an economic benefit in the large fish expected in the catch, which may be of the same order as the yield lost from smaller fish.

The yield-per-recruit method indicates a 3.7% reduction in yield that takes several years to be recouped and would result, finally, in an increase in yield of 1%. These overall changes are negligible and may be undetectable by DFO statistical systems. Even so the effect on individual components of the fishery, the small inshore vessels, can be significantly large, and as seen above, one group of vessels in St. Mary's Bay is threatened economically by the drastic reduction in a fishery directed towards other species.

Short-term losses for cod are variable and probably reflect cod distribution patterns or stock boundaries. Short-term losses for pollock and winter flounder are minimal except for winter flounder in St. Mary's Bay.

Certainly, one of the interesting observations on mesh size was the fact that what the fisherman thought he was using and what was actually measured were usually different. Further, the supposed sizes of the codends sold at various retail/wholesale outlets were not precise. This imprecision has probably been very costly to the fishing industry permitting recruitment over-fishing. On the other hand the 'non-heat-set' nets which stretched excessively permitted escapement of small fish.

Currently, fishermen may purchase any mesh size to make a codend. During the study, observed codends were made from small meshed "redfish" or flounder nets 102-108 mm (4-4¼") to groundfish nets of 140 mm (5½"). In one instance a liner was found which was made from any available material such as those used in pelagic gears. These practices will no doubt continue even with an increase in mesh size. DFO should investigate the current retailing of codend materials and if necessary restrict the sale of codends to the regulated size of 130 mm.

The recent move by the USA to a minimum landed size for haddock is favoured by some members of DFO. Theoretically, the imposition of a minimum landed size should cause the fishermen to convert to a larger codend mesh which would decrease the time spent culling the catch. However, the alternative of controlling the size of landed haddock, with or without a concurrent control on mesh size would result in significant losses in landed weight through discarding. One possible management option to compensate for the discarding would be to decrease the quota. Without an appreciable increase in landed price no immediate benefits would be envisioned by imposing a minimum landed size for haddock.

The St. Mary's Bay area is unique in that there is a large concentration of processors and fishermen. Approximately 43% of all the licensed TC 1 vessels reside and fish either in or near the bay. These vessels are dependent upon haddock and winter flounder. With the imposition of a 130 mm mesh regulation, the small vessel winter flounder fishery in St. Mary's Bay would be reduced by 50% in landed weight and revenues. This would no doubt eliminate the small otter trawler fleet in the bay. These vessels would then be faced with concentrating their efforts on other fisheries for which they are licensed (eg. lobster). This event could be viewed as both beneficial to the fishery as a whole and a loss to the groundfish industry.

The question of whether the small vessels would choose to leave St. Mary's Bay and fish haddock in other areas is more a socio-economic question than biological. Some of these vessels already fish outside the bay. The same sized vessels, from the Cape Sable Island area, were observed on Georges Bank a distance comparable to, but more treacherous than, travelling out of St. Mary's Bay. Certainly, the St. Mary's Bay vessels could travel the length of the bay to fish the adjacent grounds off Lurcher Shoal and Digby Neck which are perhaps the richest fishing grounds for haddock and cod in the area studied.

This report proposes four options for St. Mary's Bay.

1. Impose a 130 mm codend mesh universally. This would no doubt eliminate most of the TC 1 vessels fishing in the bay.

2. Leave mesh size unchanged but draw a perpendicular line from Petit Passage across the bay. Fishing within the box formed from this line to the head of the bay would be restricted to vessels less than 40' LOA (ie. mostly TC 1 vessels).

3. Increase the codend mesh size for St. Mary's Bay from the average observed of 110 to 120 mm rather than the proposed 130 mm. There already is a precedent for such an exemption from the universality of the 130 mm mesh regulation. Metuzals (1981) working on Gulf of St. Lawrence winter flounder predicted no long-term increase in yield if the codend mesh was increased from 120 to 130 mm. The fishing areas adjacent to Prince Edward Island were exempted from the 130 mm codend regulation. An increase to 120 mm would decrease the revenue losses for these vessels. A directed winter flounder fishery could be conducted with relatively low by-catches of cod and haddock. However, the lobster by-catch problem would still remain as it has for as long as these vessels have fished the bay.

4. There is one further option which DFO could impose on the study area and that is the "Status Quo". This option assumes that the

small increase in haddock long-term yield will not be altered by recruitment fluctuations. Further, it does not comment on the effect mesh size increases will have on the long-term yields of cod, pollock, and winter flounder. McCracken (1977) calculated long-term gains of 4% and 7% for northwest Atlantic cod stocks by increasing the mesh size from 120 to 127 mm. Long-term yield increases to the 4VWX pollock and winter flounder fisheries are not available. However, Metuzals (1981) predicted no long-term increase in winter flounder yields if the codend mesh was increased from 120 to 130 mm.

To exclude the 4X area from mesh regulations comparable to other areas in Scotia-Fundy would be unacceptable, in particular, TC 3-5 vessels from 4X fish in adjacent areas. Under current regulations they would be forced to return to a port and off-load their smaller meshed gear before fishing. It is unlikely that this option would be favoured by either the fishermen or DFO.

Economic analysis provides no encouragement for or against the imposition of a universal 130 mm codend regulation except in St. Mary's Bay where many TC 1 vessels and several small fish plants who depend upon small fish would be forced out of business. There are no reported price differentials between small and large haddock sold to fish plants in southwest Nova Scotia by independent operators. This uniform price paid to haddock fishermen in the study area often means the processor is buying small fish at a loss.

In relative terms the predicted losses in catch can be translated into minimum economic losses to the fishermen. Such losses assume that the fishermen will not alter their fishing strategies. This is highly unlikely since many of the observed vessels could adjust their fishing effort and area fished in order to catch the quota.

Economic returns to some processors may be increased due to larger quantities of bigger haddock being landed. Benefits would be accrued by increased product yields-per-fish and an associated decrease in labour and packaging costs (see Appendix A).

This study recommends that 130 mm codends be introduced in the 4X groundfish otter trawler fleets except in St. Mary's Bay where TC 1 vessels should be permitted to use 120 mm codends. The study itself has given DFO a unique insight into a very complex fishery. To ignore further studies of this type would be a great loss. The study of processes such as the specific areas fished, species mix, the size of fish caught, discarding rates and the current gear used provide all branches with valuable information with which to improve management of the resource.

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Table 1. Relationship of the numbers and percent by TC ( ) of length overall (LOA) to tonnage class (TC) for 1981/82 licensed otter trawl vessels from statistical districts 30-38.

	LENGTH-OVERALL						ROW TOTAL
	<44	44 < 45	45 < 65	65 < 100	100 < 125	125+	
TC 1	185 (93.9)	9 (4.6)	3 (1.5)	- (-)	- (-)	- (-)	197 (52.8)
2	19 (19.0)	49 (49.0)	32 (32.0)	- (-)	- (-)	- (-)	100 (26.8)
3	- (-)	- (-)	70 (98.6)	1 (1.4)	- (-)	- (-)	71 (19.0)
4	- (-)	- (-)	- (-)	- (-)	4 (100.0)	- (-)	4 (1.1)
5	- (-)	- (-)	- (-)	- (-)	- (-)	1 (100.0)	1 (.3)
COLUMN TOTAL	204 (54.7)	58 (15.5)	105 (28.2)	1 (.3)	4 (1.1)	1 (.3)	373 (100.0)

Table 2. Number of otter trawlers fishing for haddock in NAFO Div. 4X by year, unit area and tonnage class.

YEAR	UNIT AREA	TONNAGE CLASS				TOTAL
		2	3	4	5	
1968	4XR	35	42	9	3	89
	4XM-S	43	53	52	19	167
1969	4XR	33	34	-	2	69
	4XM-S	37	51	48	19	155
1970	4XR	29	32	2	-	63
	4XM-S	38	53	32	17	140
1971	4XR	30	32	4	-	6
	4XM-S	41	48	39	19	147
1972	4XR	23	30	1	1	55
	4XM-S	32	44	27	17	120
1973	4XR	32	28	-	-	60
	4XM-S	41	37	26	14	118
1974	4XR	38	30	-	-	68
	4XM-S	45	36	22	18	121
1975	4XR	30	30	-	1	61
	4XM-S	44	40	33	21	138
1976	4XR	26	31	-	1	58
	4XM-S	42	40	28	27	137
1977	4XR	24	26	-	-	50
	4XM-S	38	39	26	30	133
1978	4XR	19	25	-	-	44
	4XM-S	40	36	29	35	140
1979	4XR	20	34	-	-	54
	4XM-S	51	48	32	29	160
1980	4XR	26	40	-	-	66
	4XM-S	68	56	26	36	186
1981	4XR	34	37	-	-	71
	4XM-S	90	62	25	32	209
AUG 1967-81	4XR	28 ± 6	31 ± 7	-	-	61 ± 12
	4XM-S	45 ± 16	44 ± 11	31 ± 9	23 ± 8	143 ± 33

Table 3. Distribution of the number and percent by ton ( ) of licensed otter trawlers in 1981-82 by statistical district (DIST) and tonnage class (TC).

TONNAGE CLASS	STATISTICAL DISTRICT						ROW TOTAL
	32	33	34	36	37	38	
1	41 (20.8)	24 (12.2)	17 (8.6)	40 (20.3)	18 (9.1)	27 (13.7)	167 (52.8)
2	21 (21.0)	17 (17.0)	7 (7.0)	15 (15.0)	14 (14.0)	16 (16.0)	90 (26.8)
3	5 (7.0)	3 (4.2)	3 (4.2)	9 (12.7)	17 (23.9)	28 (39.4)	65 (19.0)
4	3 (75.0)	- (-)	- (-)	- (-)	- (-)	- (-)	3 (1.1)
5	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	0 (.3)
COLUMN TOTAL	70 (18.8)	44 (11.8)	27 (7.2)	64 (17.2)	49 (13.1)	71 (19.0)	316 (100.0)

Table 4. Reported nominal catches (MT round) of haddock by country from NAFO Division 4X.

YEAR	CANADA (Mar)	CANADA (Nfld)	USA	USSR	SPAIN	OTHER	TOTAL	QUOTA
1968	27279	-	2858	335	116	36	30624	-
1969	27413	-	1707	-	473	19	29162	-
1970	15560	-	1639	2	370	12	17583	18000
1971	16067	-	656	97	347	1	17168	18000
1972	12391	-	411	10	470	1	13283	9000
1973	12536	-	268	14	134	6	12958	9000
1974	12243	-	662	35	97	-	13037	-
1975	15991	-	2109	39	7	2	18148	15000
1976	16294	-	972	-	95	5	17366	15000
1977	19561	-	1649	2	-	12	21224	15000
1978	25300	114	1135	2	-	27	26578	21500
1979	24287	268	69	3	-	15	24642	26000
1980[1]	28215	75	256	-	-	34	28580	28000
1981[2]	30156	113	342	-	-	16	30627	27850

[1]Provisional 25/4/81

[2]Provisional 10/4/82

Table 5. Reported nominal catches (t round) of haddock from unit areas 4Xm-r for Canadian (Maritimes and Quebec) fishery by gear type. (from O'Boyle pers. comm.)
( ) - number of samples taken by MFD

Year	Otter Trawl Side & Stern	Longline	Miscellaneous Gears	TOTAL
1968	24128 (42)	1907	1244	27279
1969	23752 (52)	2322	1339	27413
1970	11395 (23)	2867	1298	15560
1971	12001 (20)	3112 (3)	954	16067
1972	7491 (22)	3967 (7)	933 (1)	12391
1973	6050 (16)	5785 (9)	701	12536
1974	5572 (9)	6162 (10)	509 (1)	12243
1975	10500 (43)	4943 (8)	548 (1)	15991
1976	10492 (35)	4637 (6)	1165 (2)	16284
1977	14530 (70)	4035 (8)	996	19561
1978	17305 (49)	6049 (10)	1946 (4)	25300
1979	18504 (35)	4348 (12)	1435 (2)	24287
1980	20095 (34)	5717 (17)	2403 (4)	28215
1981	21246 (49)	6995 (26)	1915 (7)	30156

Table 6. Reported nominal catch (t) of 4X haddock by Canadian vessels from 1968-1981.

Tonnage Class	Unit Area	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
TC 1-3	4Xr	6530	3950	2096	1877	1603	1203	3129	2324	2107	1423	2010	1950	2987	3278
TOTAL	4X	10292	6281	4895	4289	2741	1823	3949	6092	4351	6186	9214	9870	12657	14601
TC 4-5	4Xr	47	59	2	21	24	-	-	3	4	-	-	-	-	-
TOTAL	4X	13836	17479	6517	7716	4750	4266	1623	4407	6147	8344	8091	8635	7440	6645
TOTAL	4X	24128	23760	11412	12005	7491	6089	5572	10499	10498	14530	17305	18505	20097	21246

Table 7. Reported nominal catch (t round) of 4X haddock from unit areas m-r for Canadian (MQ) otter trawl fishery. (from O'Boyle pers. comm.)

TC	AREA	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1-3	M	0	1	0	0	0	0	1	0	22	1	30	11	17	46
	N	48	614	300	192	138	31	4	154	314	390	805	1691	2774	3754
	O	1014	820	428	270	85	88	129	558	435	779	1604	1138	1934	2445
	P	1552	458	1616	1460	371	64	54	1126	329	1490	2592	1799	1087	1659
	Q	1143	437	455	490	544	435	632	1532	1131	1112	1903	2978	3698	3068
	R	6530	3950	2096	1877	1603	1203	3129	2324	2107	1423	2010	1950	2987	3278
	U	5	1	0	0	0	2	9	398	13	991	270	303	160	351
Total		10292	6281	4895	4289	2741	1823	3949	6092	4351	6186	9214	9870	12657	14601
4-5	M	28	102	45	6	8	0	20	97	79	129	208	256	288	184
	N	4098	10242	2439	4040	1700	2595	471	2078	3931	4025	3818	4732	3729	4639
	O	1778	1681	950	1025	1397	1000	550	1576	1485	2349	1828	2658	2223	1382
	P	7341	5068	2826	2370	1296	480	341	576	541	1731	1585	793	1133	392
	Q	544	319	238	250	325	154	241	77	106	41	116	52	38	1
	R	47	59	2	21	24	0	0	3	4	0	0	0	0	0
	U	0	8	17	4	0	37	0	0	1	69	536	144	29	47
Total		13836	17479	6517	7716	4750	4266	1623	4407	6147	8344	8091	8635	7440	6645
TOTAL		24128	23760	11412	12005	7491	6089	5572	10499	10498	14530	17305	18505	20097	21246

Table 8. Monthly observer coverage by statistical district and tonnage class during the 1982 4X study.

VESSEL HOME DISTRICT	TONNAGE CLASS	TRIPS (SETS) MAY	JUNE	JULY	AUG.	SEPT.	TOTAL NO. TRIPS (SETS)	TOTAL NO. UNIQUE VESSELS OBSERVED	TOTAL NO. REGISTERED VESSELS	% OBSERVED VESSELS OF REGISTERED
32	1	-	-	-	1(16)	-	1(16)	2	41	2
	2	-	3(22)	2(13)	3(20)	2(17)	10(72)	8	21	38
	3	-	2(32)	1(26)	-	-	3(58)	3	5	60
33	1	-	-	-	-	-	-	0	24	-
	2	3(47)	3(25)	1(10)	-	1(9)	8(91)	7	17	41
	3	1(3)	1(10)	1(15)	-	-	3(28)	2	3	66
34	1	-	-	1(7)	-	-	1(7)	2	17	6
	2	-	-	-	1(2)	-	1(2)	1	7	14
	3	-	-	-	1(13)	-	1(13)	1	3	33
36	1	-	1(4)	-	-	2(5)	3(9)	3	40	8
	2	-	-	1(7)	-	3(16)	4(23)	4	15	27
	3	1(10)	1(14)	-	3(22)	1(1)	6(47)	4	9	44
37	1	-	-	-	1(3)	-	1(3)	1	18	6
	2	5(26)	2(21)	-	7(36)	-	14(83)	8	14	57
	3	6(18)	5(21)	-	3(36)	2(30)	16(105)	9	17	53
38	1	-	-	2(16)	4(15)	5(21)	11(52)	7	27	26
	2	3(14)	-	-	1(4)	1(1)	5(19)	2	16	13
	3	-	-	-	-	-	-	-	28	0
TOTAL	1	0	1(4)	3(23)	6(34)	7(26)	17(87)	13	167	8
	2	11(87)	8(68)	4(30)	13(62)	7(43)	43(290)	31	90	34
	3	8(31)	9(77)	2(41)	7(71)	3(31)	10(251)	19	65	29
OVERALL TOTAL		19(118)	18(149)	9(94)	26(167)	17(100)	88(628)	64	322	20

Table 9. Observed catches (t) from the 4X groundfish fishery by set.

VESSEL HOME STAT. DISTRICT	TONNAGE CLASS	AREA FISHED	NUMBER OF SETS OBSERVED	OBSERVED SPECIES CATCH (t)			
				COD	HADDOCK	POLLOCK	WINTER FLOUNDER
32	1	5Zj	15	5.89	.18	.07	-
	2	4Xn	5	.29	1.65	.01	-
		4Xo	24	1.42	7.28	.30	.23
		4Xp	12	.89	1.03	.52	-
		4Xq	2	.25	.60	-	.05
		5Zj	29	29.40	5.56	.19	-
	3	4Xn	14	.59	10.61	.47	-
		4Xo	14	.74	.38	7.34	-
		4Xp	9	1.18	5.55	.42	-
		5Zj	17	46.04	.90	.33	-
33	2	4Xo	17	1.42	2.61	.005	1.66
		4Xp	1	.03	.11	.02	.04
		4Xq	48	7.42	8.17	10.55	2.93
		5Zj	18	24.75	2.02	.15	.01
	3	4Xo	1	.01	.15	-	-
		4Xp	1	.05	.13	-	-
		4Xq	2	.25	.70	1.00	-
		5Zj	24	41.40	3.65	.17	.01
34	1	4Xr	7	.27	4.09	.13	.17
	2	4Xq	2	.11	.25	.02	.04
	3	4Xq	10	.76	.30	8.48	-
36	1	4Xr	7	.19	1.09	-	.22
	2	4Xq	6	1.99	2.37	1.00	.19
		4Xr	13	3.23	20.61	.03	.03
	3	4Xp	10	2.48	8.13	.08	1.20
		4Xq	1	.25	.20	.02	-
		4Xr	20	12.56	10.20	.52	.54
		4Xs	2	.42	.80	.03	-
		5Y	12	2.89	4.17	.23	.06
37	1	4Xr	1	-	.49	-	-
	2	4Xr	75	27.99	23.24	14.12	2.20
	3	4Xq	15	1.06	.59	15.08	-
		4Xr	64	20.50	16.06	9.86	.13
		4Xs	10	1.25	1.30	.95	.18
		5Y	11	1.04	.36	.23	.01
38	1	4Wk	1	.03	-	-	-
		4X	13	.002	-	-	1.93
		4Xn	1	.005	-	-	.01
		4Xr	22	1.08	.93	.02	4.15
	2	4X	2	.007	-	-	.26
		4Xr	16	10.90	.23	.19	.66

Table 10. Reported 4X landings in 1981 and 1982.

Species	Size	1982 Jan-Sept	1981 Jan-Sept
Cod	25 GT	700	411
	65'	4790	4533
	65'-99'	14	143
	100'-124'	7	28
	+125	1361	285
	Total	6872 (6871)	5400
Haddock	25 GT	886	628
	65'	7532	10612
	65'-99'	142	563
	100'-124'	92	399
	+125	1812	2773
	Total	10464 (10478)	14975
Pollock	25 GT	84	22
	65'	5171	3418
	65'-99'	63	141
	100'-124'	259	124
	+125	3010	3557
	Total	8587 (8589)	7262
Winter Flounder	25 GT	735	513
	65'	8	1
	65'-99'	-	-
	100'-124'	-	-
	+125	9	2
	Total	752 (752)	516
Flounder	25 GT	9	3
	65'	947	1248
	65'-99'	4	20
	100'-124'	-	-
	+125	1	-
	Total	961	1271

Table 11. Summary of observer sampling coverage by vessel home port, TC, and species during the 1982 mesh size study.

Home Port Statistical District	Tonnage Class	Sampling Coverage							
		Number of Sets Sampled				Number Lengths Measured			
		COD	HAD	POK	FLW	COD	HAD	POK	FLW
32	1	6	3	-	-	814	89	-	-
	2	17	31	-	-	1667	3134	-	-
	3	3	20	-	-	326	1614	-	-
	TOTAL	26	54	-	-	2807	4837	-	-
33	2	6	38	3	3	322	1535	210	92
	3	3	11	-	-	198	412	-	-
	TOTAL	9	49	3	3	520	1947	210	92
34	1	-	3	-	-	-	233	-	-
	2	-	2	-	-	-	191	-	-
	3	1	3	4	-	3	40	480	-
	TOTAL	1	8	4	-	3	464	480	-
36	1	1	2	-	-	14	146	-	-
	2	1	4	-	-	34	554	-	-
	3	2	6	-	-	201	296	-	-
	TOTAL	4	12	-	-	249	996	-	-
37	1	-	1	-	-	-	90	-	-
	2	15	29	3	7	871	2549	197	678
	3	25	42	18	2	1291	2151	632	26
	TOTAL	40	71	21	9	2162	4790	829	704
38	1	4	3	1	16	178	124	1	1809
	2	10	1	-	4	703	15	-	450
	TOTAL	14	4	1	20	881	139	1	2259
ALL	1	11	12	1	16	1006	682	1	1809
	2	49	105	6	14	3597	7978	407	1220
	3	34	82	22	2	2019	4513	1112	26
	TOTAL	94	199	29	32	6622	13173	1520	3055

Table 12. Percent coverage of the 1982 4X mail survey.

STATISTICAL DISTRICT	NUMBER MAILED	NUMBER RETURNED	PERCENT COVERAGE
22-31	91	38	42
32	61	10	16
33	39	12	31
34	21	6	29
36	58	18	31
37	39	21	54
38	59	26	44
Other Scotia-Fundy Divisions	64	15	23
TOTAL	432	146	34

Table 13. Summary of mesh size distribution from information obtained from a survey mailed to 4X haddock fishermen in 1982.

Statistical District	Tonnage Class 1		2		3		4		Not Active	Total
	120	130	120	130	120	130	120	130		
22 - 31	3	6	1	5	3	2	-	14	4	38
32	2	1	1	3	1	2	-	-	-	10
33	2	5	2	2	-	-	-	-	1	12
34	2	3	-	1	-	-	-	-	-	6
36	3	3	3	3	3	3	-	-	-	18
37	4	1	3	3	6	2	-	-	2	21
38	4	-	5	2	4	6	-	-	5	26
Other Scotia-Fundy Areas	4	3	2	2	-	1	-	-	3	15
TOTAL (%)	24 (52)	22 (48)	17 (45)	21 (55)	17 (52)	16 (48)	-	14	18	146
% OF TOTAL	16	15	12	14	12	11	-	10	12	100

Table 14. Summary of the fishermen and processor interview coverage by statistical district during the 1982 4X study.

COUNTY	STATISTICAL DISTICT	FISHERMAN INTERVIEW NUMBER FISHING	NUMBER INTERVIEWED	% INTER-VIEWED	PROCESSOR INTERVIEW NUMBER PROCESSING HADDOCK	NUMBER INTERVIEWED	% INTER-VIEWED
Lunenburg	26				6	1	17
Shelburne	32	70	5	7	10	2	20
Yarmouth	33	44	19	43	11	2	18
	34	27	5	19			
Digby	36	64	10	16	20	6	30
	37	49	8	16			
	38	71	9	13			
TOTAL		325	56	17	47	11	23

Table 15. Summary of mesh size information obtained from interviews with 4X haddock fishermen in 1982.

Statistical District	Tonnage Class 1		2		3		Total
	120	130	120	130	120	130	
32	-	2	-	2	-	1	5
33	2	5	5	4	-	3	19
34	2	-	1	-	-	2	5
36	2	1	1	-	3	3	10
37	1	-	3	-	2	2	8
38	5	-	3	1	-	-	9
TOTAL (%)	12 (60)	8 (40)	13 (65)	7 (35)	4 (27)	11 (73)	56
% OF TOTAL	21	14	23	13	7	20	100

Table 16. Summary of mesh size data collected by onboard observers in 1982 and grouped for unique vessels by tonnage class and statistical district.

Statistical District	Tonnage Class 1			2			3			Total
	<120	120 -129	130+	< 120	120 -129	130+	< 120	120 -129	130+	
32	-	1	1	1	6	2	-	1	2	14
33	-	-	-	-	5	-	-	-	3	8
34	2	1	-	-	-	-	-	-	1	4
36	2	1	-	1	1	1	-	3	2	17
37	2	-	-	2	2	1	3	1	5	16
38	7	-	-	1	1	-	-	-	-	9
TOTAL	13 (76)	3 (18)	1 (6)	5 (22)	14 (61)	4 (17)	3 (14)	6 (27)	13 (59)	62
% OF TOTAL	21	5	2	8	23	6	5	10	21	100

Table 17. Summary of codend mesh measurements taken by observers using DFO gauges during the 1982 4X study.

VESSEL'S HOME STAT. DISTRICT	TONNAGE CLASS 1		2		3	
	NO TRIPS	MEAN ± STD.	NO TRIPS	MEAN ± STD.	NO TRIPS	MEAN ± STD.
32	1	132.5 ± 0.0	10	126.5 ± 8.6	3	132.3 ± 6.8
33	-	-	8	125.5 ± 3.9	3	131.0 ± 1.7
34	1	113.0 ± 0.0	1	125.0 ± 0.0	1	132.0 ± 0.0
32-34	2	122.8 ± 0.0	19	126.0 ± 6.5	7	131.7 ± 4.3
36	3	113.0 ± 9.5	4	127.6 ± 10.4	6	127.3 ± 2.3
37	1	121.0 ± 0.0	14	123.1 ± 12.0	16	121.4 ± 7.3
38	11	110.8 ± 2.2	5	118.6 ± 6.0	-	-
36-38	15	111.9 ± 3.8	23	122.9 ± 10.4	22	123.0 ± 5.9
TOTAL (32-38)	17	113.2 ± 4.2	42	124.3 ± 8.7	29	125.1 ± 5.6

Table 18. Summary of information from 12 fisheries officers interviewed during 1982 in the Southwest Nova area.

No. of Fisheries Officers	Area of Responsibility (Stat. Dist.)	Experience (Years)	Mesh Size Currently In Use	Vessel (LOA) Category (Feet)	Management Options							Location Of Small Haddock
					Minimum Mesh Size	Minimum Landed Size	Closed Nursery Areas	Universality Minimum Mesh Size	Tolerance Mesh Size	Quality Improvement	Fleet Reduction	
1	38-39	25	120, 130	40-65	-	Yes	Yes	Yes 130	None	-	-	-
2	37, 38, 39	25	120, 130	40-65	N/A	Yes	Yes	N/A	N/A	-	-	-
3	34	5	Unknown	Unknown	Yes	Discarding Problem	Yes	No - 4Xr Exception	-	-	-	-
4	33, 34, 36	10	Most 120 Some 130	-	Yes	"	Yes	Yes	None	Yes	-	Herring spawning areas Aug. and Sept. e.g. Trinity and Lurcher Banks
5	36	5	120 and 120	40 40	Yes	No	Yes	Yes	None	Yes	Yes	-
6	37	10	120 and 120	38-45 45	Yes at sales outlet	Yes	Browns Bank	Yes 130	None	-	-	St. Mary's Bay - late summer and fall
7	-	20	120 and 120	38-45 45	No	Yes	Yes	Yes	None	-	Yes	St. Mary's Bay
8	38	5	110-120 120-130	38-45 45	Yes	Yes	No	Yes	10%	-	-	St. Mary's Bay and Lurcher Bank
9	37	25	90-125	35-44	Yes	Yes	Yes	Yes 130	3mm	Yes	Yes - one dragger increase only per year	St. Mary's Bay (spring to fall) Lurcher-Trinity (fall)
10	39	25	130	-	No	No	Yes	No - 4Xr only 120	None	-	-	-
11	36	10	120 and 120	40 40	Yes	No	Yes	No - 4Xr only 120	-	-	-	-
12	33	5	120, 130	65	Yes	Yes with min. mesh size	Yes	Yes	None officially 3mm unofficially	Yes	-	Bay of Fundy shallow areas

Table 19. Comparison of observed codend mesh size changes from dry to wet for two manufacturing methods during the 1982 4X study.

Nets initially sold as (mm)	NET MANUFACTURING METHOD			
	Heat Set		Non-Heat Set	
	# Vessels	Mean Mesh (mm)	# Vessels	Mean Mesh (mm)
<120	5	110 ± 4.8	6	108 ± 7.2
120	16	122 ± 1.4	13	129 ± 4.0
130	13	129 ± 2.1	3	138 ± 1.3

Table 20. Summary of onboard mean wet codend mesh measurements (mm) collected by observers for two manufacturing methods during the 1982 4X study.

Nets initially sold as (mm)	NET MANUFACTURING METHOD			
	No. Vessels	Heat-Set mean difference (dry-wet) (mm)	No. Vessels	Non-Heat-Set mean difference (dry-wet) (mm)
<120	5	.6 ± 2.4	5	.2 ± 1.0
120	14	.4 ± 0.6	11	-.6 ± 2.1
130	11	.3 ± 1.2	3	-.7 ± 4.0

Table 21. Summary of average mean wet measurements (mm) by age and mesh size category for heat-set and non-heat-set codends, (STD), and no. of vessels.

AGE (months)	SOLD AS (mm)	HEAT-SET (mm)	NON-HEAT-SET (mm)
0-6	< 120	107 (6.2) 3	112 (2.3) 4
	120	124 (3.1) 5	131 (6.0) 8
	130	127 (3.9) 3	138 (-) 1
6-12	< 120	-	-
	120	122 (1.0) 2	130 (-) 1
	130	136 (-) 1	-
12	< 120	114 (4.0) 2	101 (21.6) 2
	120	119 (1.0) 2	125 (-) 1
	130	129 (4.7) 4	138 (3.0) 2

Table 22. Change in yield calculations from direct observations of the fishery in 1982. 1981 catch data from reported statistics.

Vessels Home Stat. DIST.	Tonnage Class	Mean Mesh (mm)	HADDOCK %	HADDOCK 1981 catch t	HADDOCK Est. Loss in 1981 (t)	Cod %	POLLOCK %	WINTER FLOUNDER %
32	2	122	15.0	1576	236	54.6	-	-
	3	125	9.2	645	59	-	-	-
33	2	122	11.1	1662	184	3.0	<.1	.1
34	1	113	32.2	431	139	-	-	-
	2	125	8.7	156	14	-	-	-
36	1	119	45.2	190	86	1.5	-	-
	2	120	14.0	850	119	4.6	-	-
	3	126	9.6	1506	145			
37	1	121	9.0	346	31	-	-	-
	2	121	13.7	938	129	8.0	6.7	35.9
	3	119	6.0	2191	131	13.0	1.4	2.8
38	1	112	74.2	19	14	5.2	-	27.2
	2	123	5.9	298	18	7.8	-	34.7
TOTAL (32-38)	1	116	27.4	986	270			
	2	122	12.8	5480	700			
	3	123	7.7	4342	335			
Grand TOTAL			12.1	10808	1305			

Table 23. Calculations of new 4X haddock partial recruitment patterns (PR) in 1981 of a change from 120 - 130 mm codend.

Age	F_{TOT}	C_{TOT} ('000)	C_{OT} ('000)	C_1 ('000)	C_2 ('000)	F_1	F_2	S_{120}	S_{130}	$F_{1,120}$	$F_{TOT, BO}$	PR (OLD)	PR (NEW)
1	0.000	2	0	1	0	0	0	0.02	0.01	0	0	0.00006	0.00001
2	0.016	1143	1134	908	226	0.013	0.003	0.28	0.12	0.006	0.009	0.040	0.023
3	0.120	2176	2099	1448	651	0.080	0.040	0.68	0.47	0 055	0.095	0.300	0.238
4.	0.240	6177	4488	2882	1606	0.112	0.128	0.90	0.76	0.095	0.223	0.600	0.558
5	0.400	4180	3202	1984	1218	0.190	0.210	0.97	0.91	0.178	0.388	1.000	0.970
6	0.400	3190	2094	1381	713	0.173	0.227	0.99	0.97	0.170	0.397	1.000	0.993
7	0.400	1169	741	501	240	0.171	0.229	1.00	0.96	0.164	0.393	1.000	0.983
8	0.400	373	158	115	43	0.123	0.277	1.00	1.00	0.123	0.400	1.000	1.000
9	0.400	327	169	125	44	0.153	0.247	1.00	1.00	0.153	0.400	1.000	1.000
10	0.400	97	52	38	14	0.157	0.243	1.00	1.00	0.157	0.400	1.000	1.000
11	0.400	14	5	3	2	0.086	0.314	1.00	1.00	0.086	0.400	1.000	1.000
12	0.400	33	6	3	2	0.036	0.364	1.00	1.00	0.036	0.400	1.000	1.000

Table 24. Data used for Yield-per-recruit and projections for longterm impact of changing from 120 - 130 mm codends for 4X haddock.

Age	Population Numbers 1981 ('000)	Total Catch 1981 ('000)	Mean Weight (kg)	Partial Recruitment Old	Partial Recruitment New
1	91945	2	0.23	0.00006	0.00001
2	79430	1143	0.59	0.040	0.023
3	21189	2176	0.88	0.300	0.238
4	31814	6177	1.26	0.600	0.558
5	13897	4180	1.72	1.000	0.970
6	10605	3190	2.22	1.000	0.993
7	3886	1169	2.65	1.000	0.983
8	1240	373	3.15	1.000	1.000
9	1087	327	3.65	1.000	1.000
10	322	97	3.70	1.000	1.000
11	47	14	4.51	1.000	1.000
12+	73	33	4.83	1.000	1.000

Table 25. Yield-per-recruit and projections for 4X haddock. Original weights, partial recruitment, catch and numbers-at-age from O'Boyle and White, 1982.

(1) Current Partial Recruitment

	Fishing Mortality	Catch (Number)	Yield (kg)	Avg. Weight (kg)	Yield per Unit Effort
$F_{0.1}$	0.271	0.316	0.603	1.891	0.480
F_{max}	0.561	0.422	0.655	1.551	0.253

(2) New Partial Recruitment at 130 mm Codends

	Fishing Mortality	Catch (Number)	Yield (kg)	Avg. Weight (kg)	Yield per Unit Effort
$F_{0.1}$	0.278	0.312	0.608	1.945	0.477
F_{max}	0.595	0.416	0.662	1.593	0.243

Table 26. Projected changes in 4X haddock yields (t) based on 1981 data and yield-per-recruit calculations.

Mesh Size	Yearly catch (t) after imposition of new regulations										
	0	1	2	3	4	5	6	7	8	9	10
Current	30692	24343	29480	35009	36319	33918	31476	29550	27854	26509	25929
New	30692	23445	28704	34844	36656	34287	31794	29867	28110	26734	26136
Gain in Yield	0	-898	-776	-165	337	369	318	317	256	225	207
Accumulated Gain	0	-898	-1674	-1839	-1502	-1133	-815	-498	-242	-17	190
% Increase in Catch	0	-3.7	-2.6	-.5	.9	1.1	1.1	1.1	.9	.9	.8

Table 27. Calculated short term losses in yield and landed value for the 4X haddock fishery based on 1982 observations and 1981 data.

TONNAGE CLASS	EST. % LOSS IN YIELD/OR INCREASE IN EFFORT	1981 LANDED CATCH (t)	EST. LOSS IN YIELD (t)	1981 LANDED VALUE ($'000)	EST. LOSS IN 1981 LANDED VALUE ($'000)*
1	27.4	2024	555	876	240
2	12.8	6480	829	3050	390
3	7.7	6278	483	3234	249
4-5	0.0	6647	-	2659	-
O.T. FLEET	8.7	21429	1867	9819	879
TOTAL FISHERY	6.2	30156	1867	14177	879

* Assumes no price differentiation by port of landing, season, and size of fish. Calculated by (Landed Value x % loss of Yield).

Table 28. Calculated immediate losses by imposing a 120 versus a 130 mm regulation for TC 1 vessels residing inside St. Mary's Bay.

Species	% Loss (110-120 mm)	% Loss (110-130 mm)
Cod	2.4	5.2
Haddock	41.0	74.2
Winter Flounder	7.0	27.2
Pollock	0.0	0.0

Table 29. Effects of imposition of a minimum size landed at the current and new mesh sizes over a three year period

Recruitment Pattern	Mesh Size	Average Yearly Catch (t)	Average Yearly Discards (t)	Percentage Discarded	Average Yearly % increase in effort
Current	Current	43302	11302	35	35
	New	41075	9075	28	28

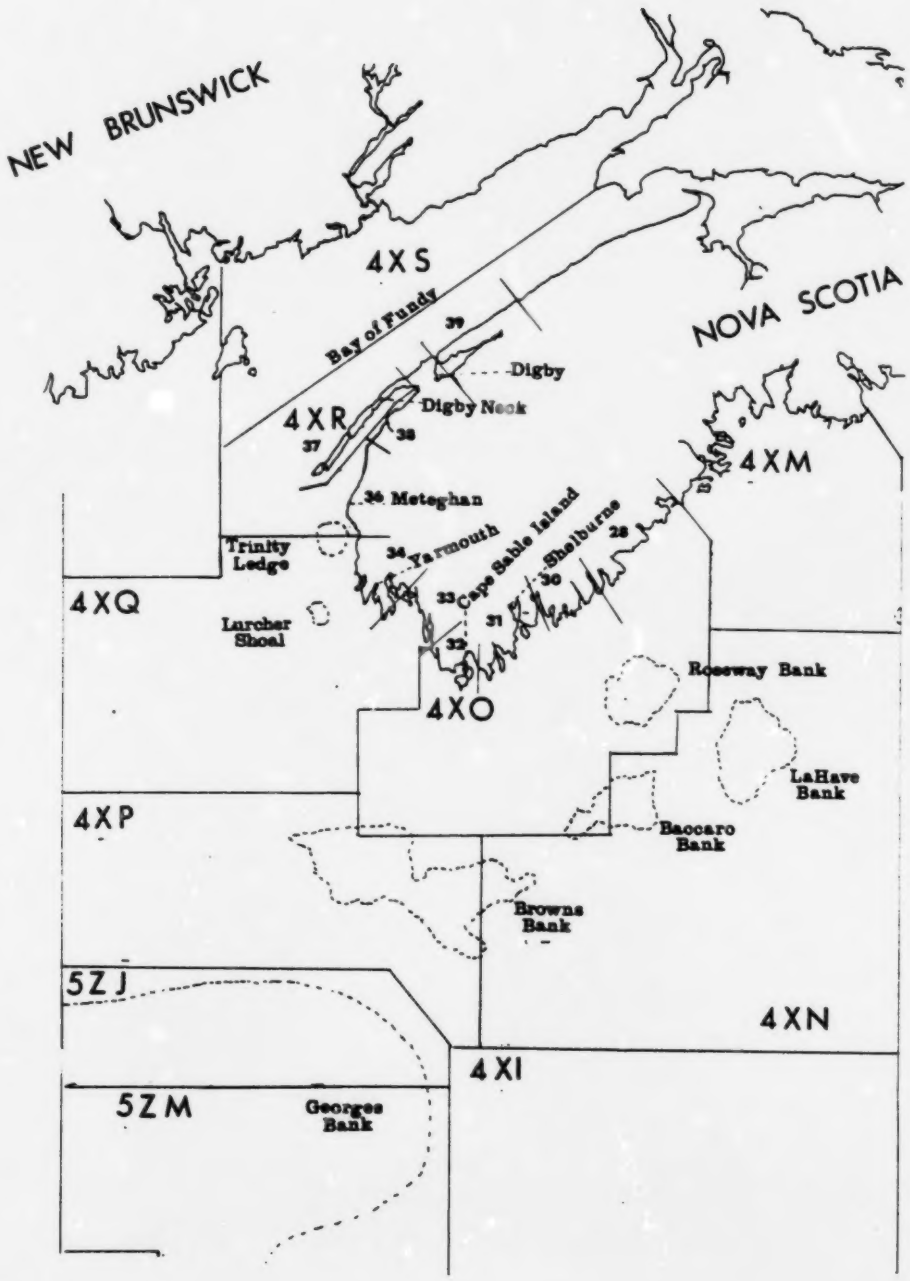

Figure 1. NAFO unit areas (4Xm-5Zm) and DFO statistical areas (28-40) surveyed during the 1982 4X study.

Codend Mesh Information
4X Haddock Study

Name _____
No. of Vessels Owned _____ Home Port _____
Vessel Name(s) _____ CFV No(s) _____
_____ _____
_____ _____
_____ _____
_____ _____

Has your vessel(s) participated in the groundfish fishery during the past 12 months? (Please check) Yes ☐ No ☐

What codend mesh size are you currently using? 4 3/4" (120 mm) ☐
5 1/8" (130 mm) ☐

From which sales outlet did you purchase this codend?
Leckies (IMP) ☐
Gourock Industries Ltd. ☐
Fundy Twine Ltd. ☐
IC ☐
Other _____ ☐
(specify)

Figure 2. Questionnaire used in the survey mailed to the 4X naddock fishermen in 1982.

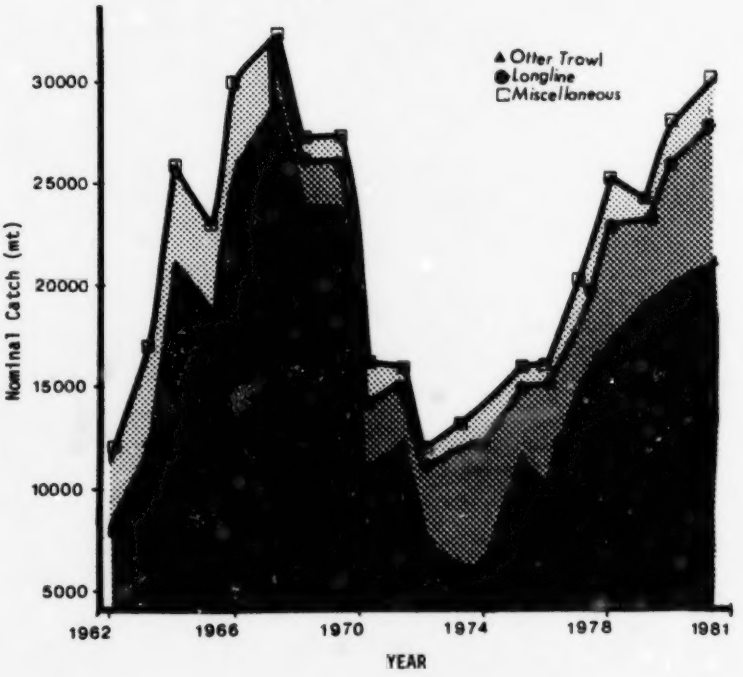

Figure 3. Reported cummulative catches (t) of 4X haddock for various Canadian fishing fleets.

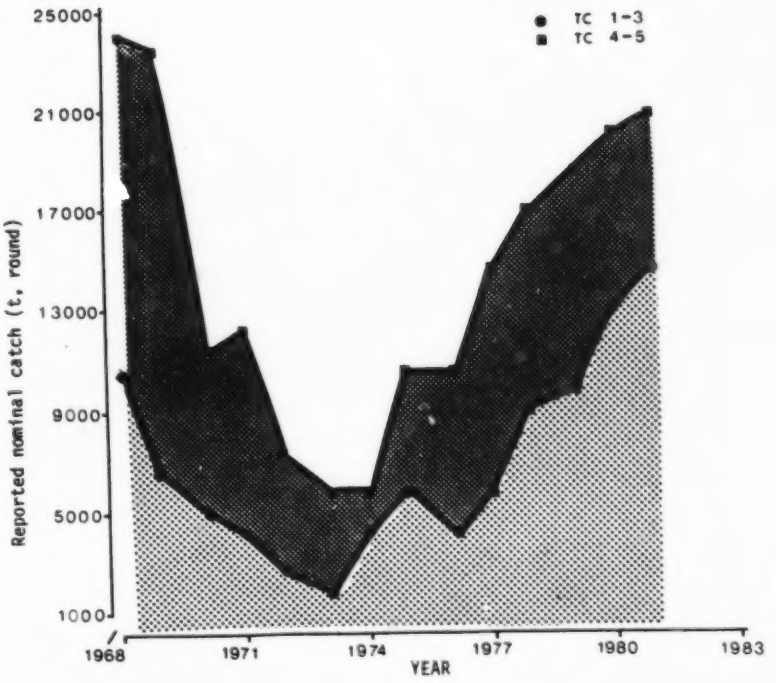

Figure 4. Reported cummulative catches (t) of 4X haddock for the Canadian Otter Trawl Fleet by tonnage class (TC).

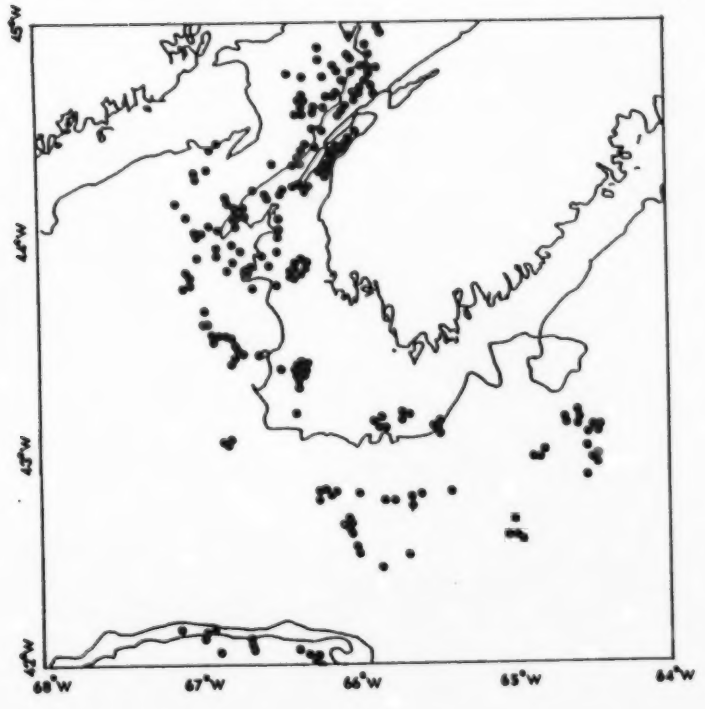

Figure 5. Set locations observed during the 1982 4X study.

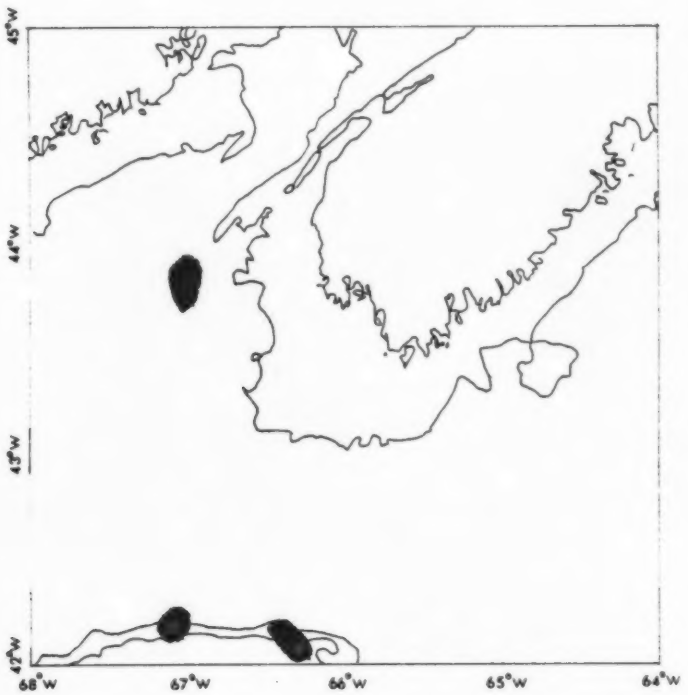

Figure 6. Distribution of observed haddock catches (kg/tow) by TC 1 vessels from ports in Statistical Districts 32-34. (shading in all figures represents relative density of catches).

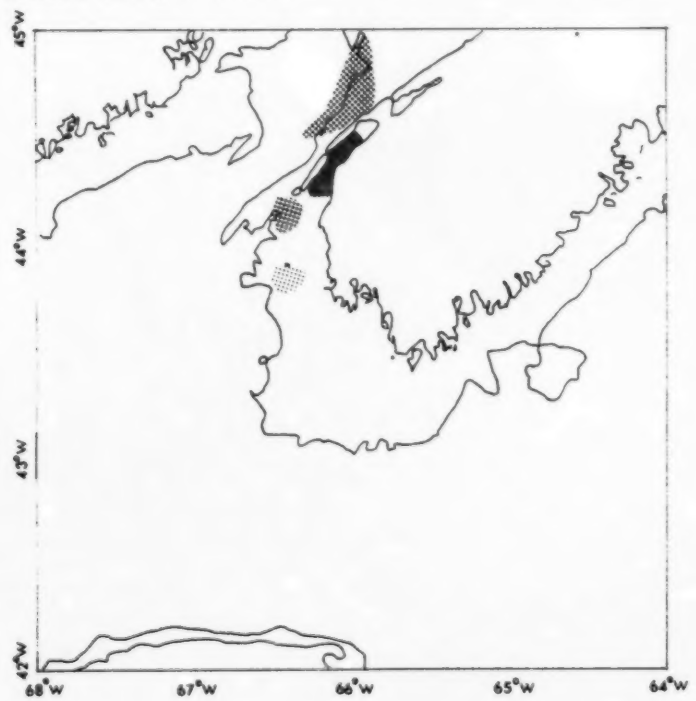

Figure 7. Distribution of observed haddock catches (kg/tow) by TC 1 vessels from ports in Statistical Districts 36-38.

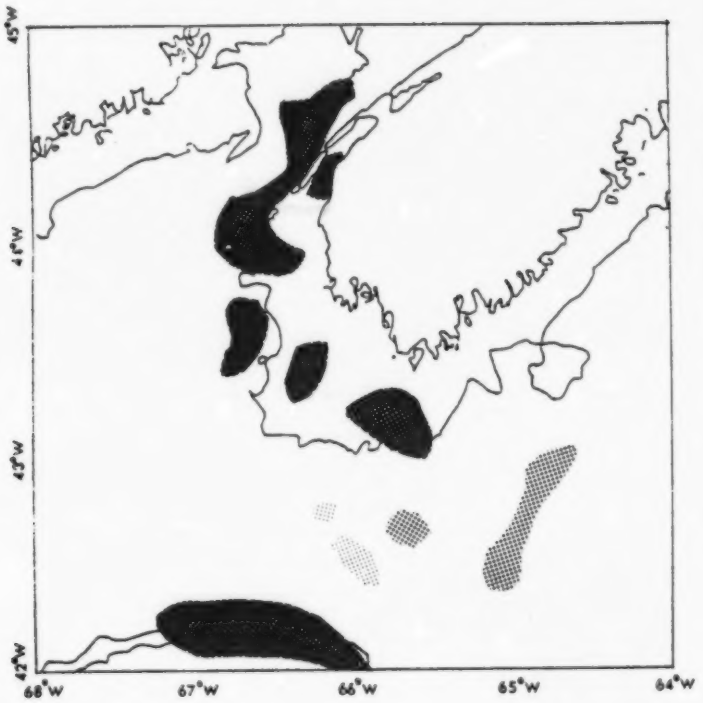

Figure 8. Distribution of observed 1982 haddock catches by TC 2 vessels.

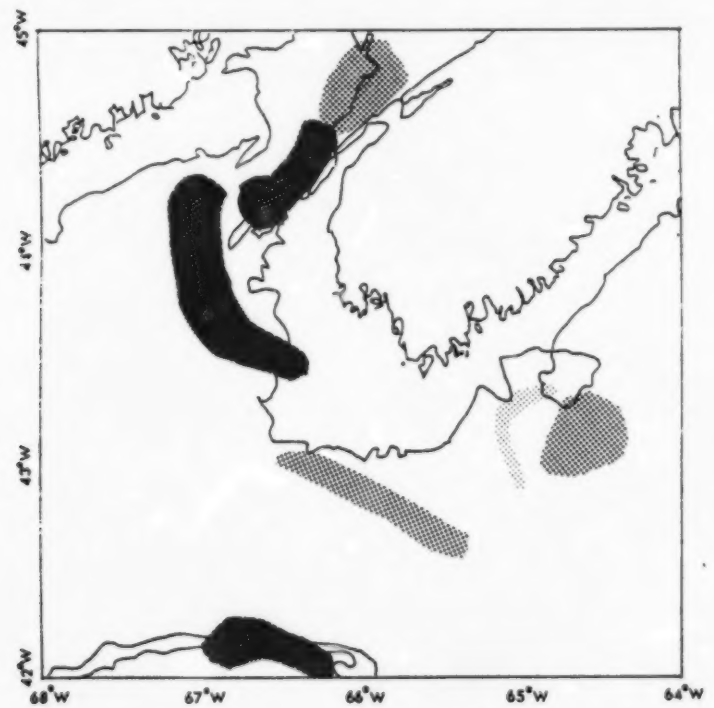

Figure 9. Distribution of observed 1982 haddock catches by TC 3 vessels.

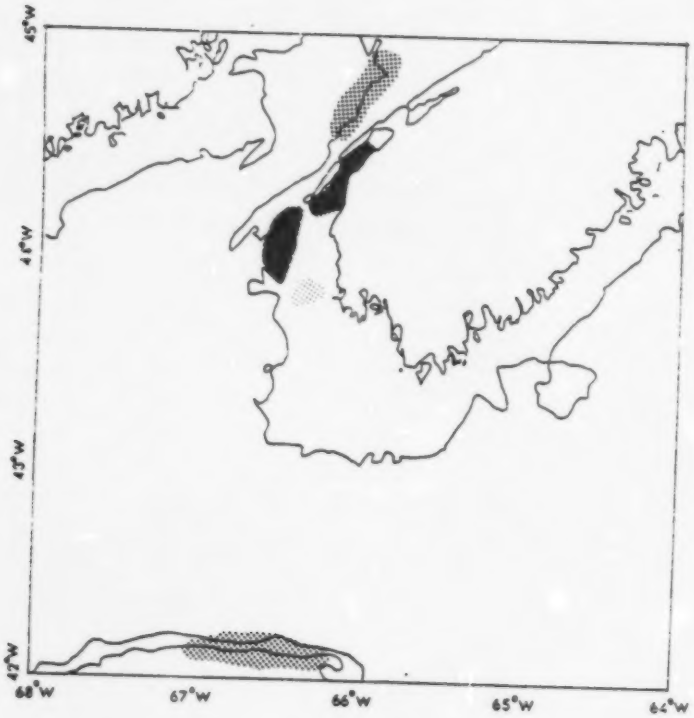

Figure 10. Distribution of observed 1982 haddock catches by tonnage class 1 (TC 1) vessels.

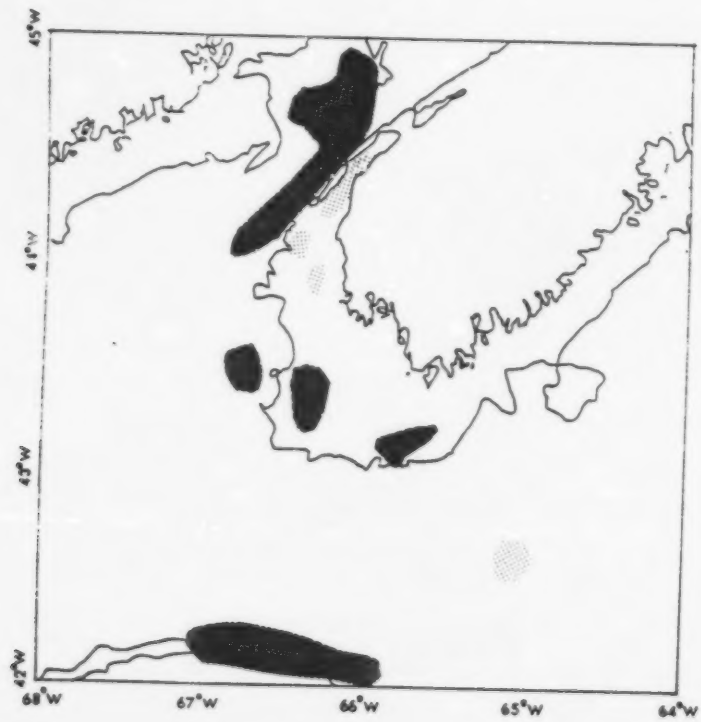

Figure 11. Distribution of observed 1982 cod catches for TC 1 and TC 2 vessels.

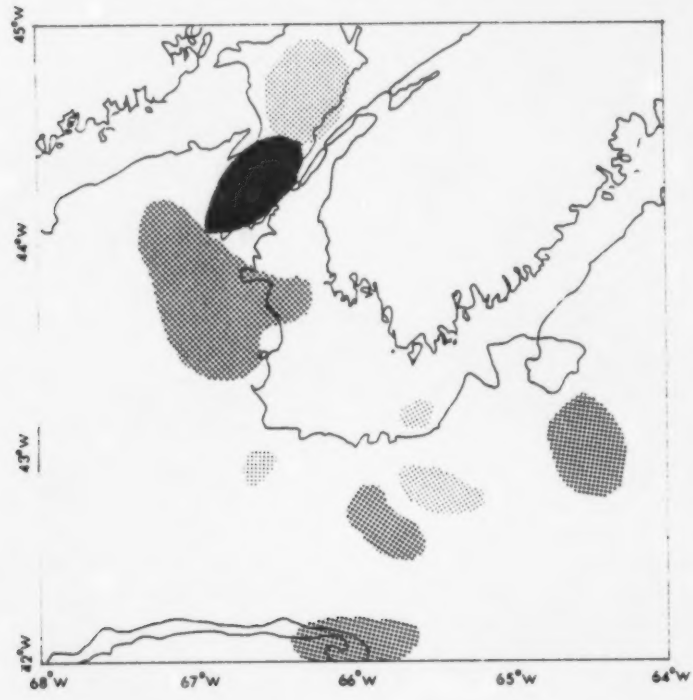

Figure 12. Distribution of observed cod catches (kg/tow) by TC 3 vessels during the 1982 4X study.

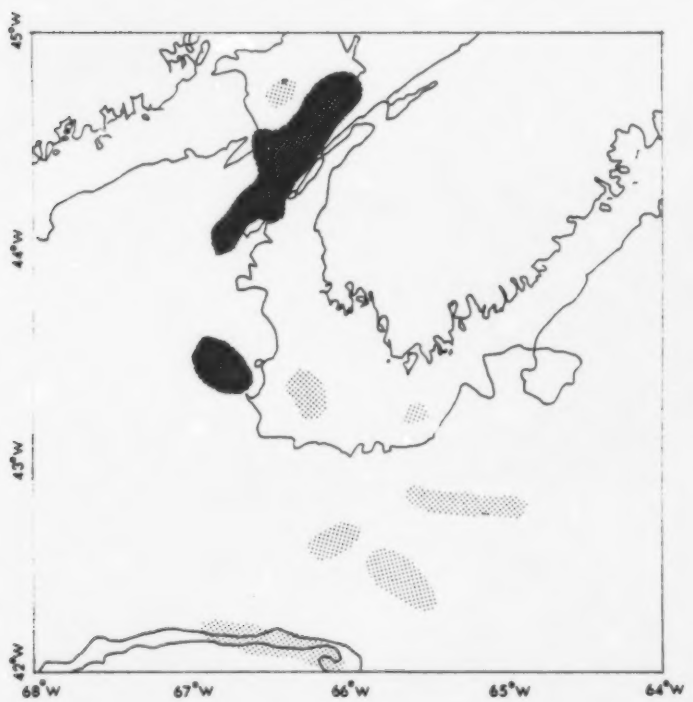

Figure 13. Observed pollock catches (kg/tow) by TC 2 vessels during the 1982 4X study.

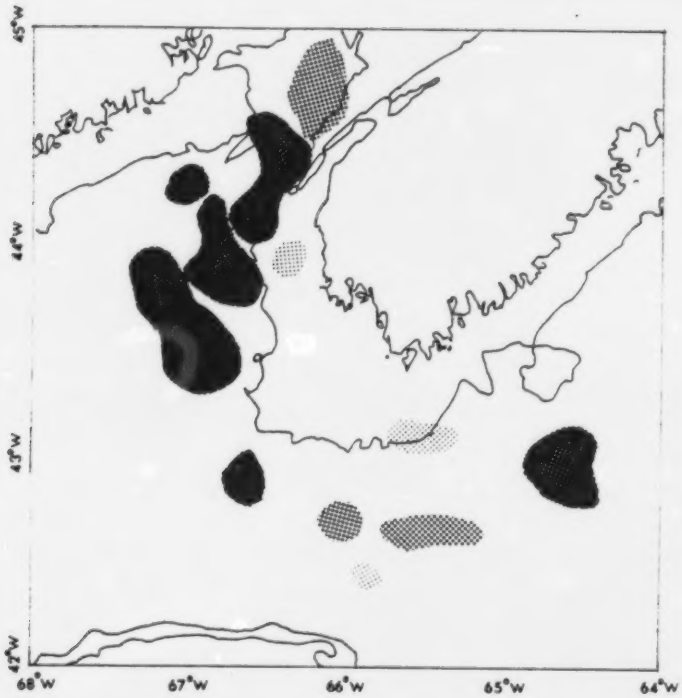

Figure 14. Observed pollock catches (kg/tow) by TC 3 vessels during the 1982 4X study.

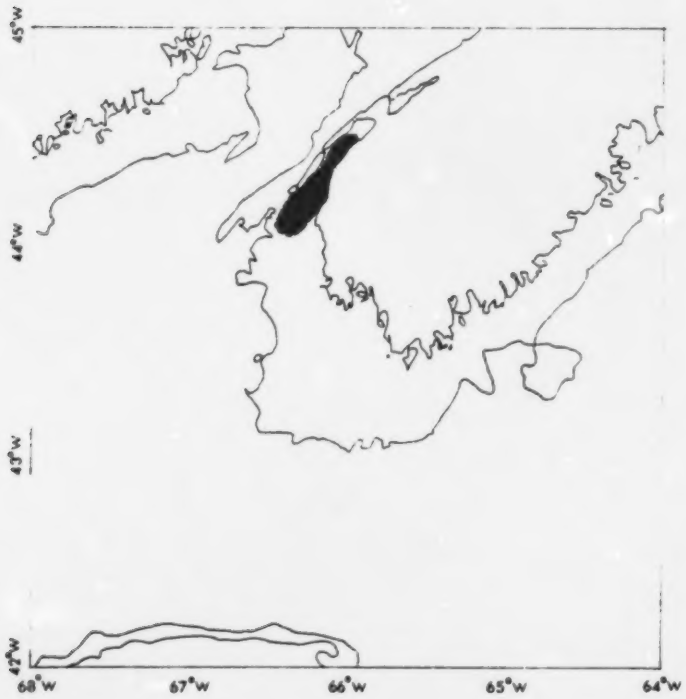

Figure 15. Observed winter flounder catches by TC 1 vessels resident in St. Mary's Bay.

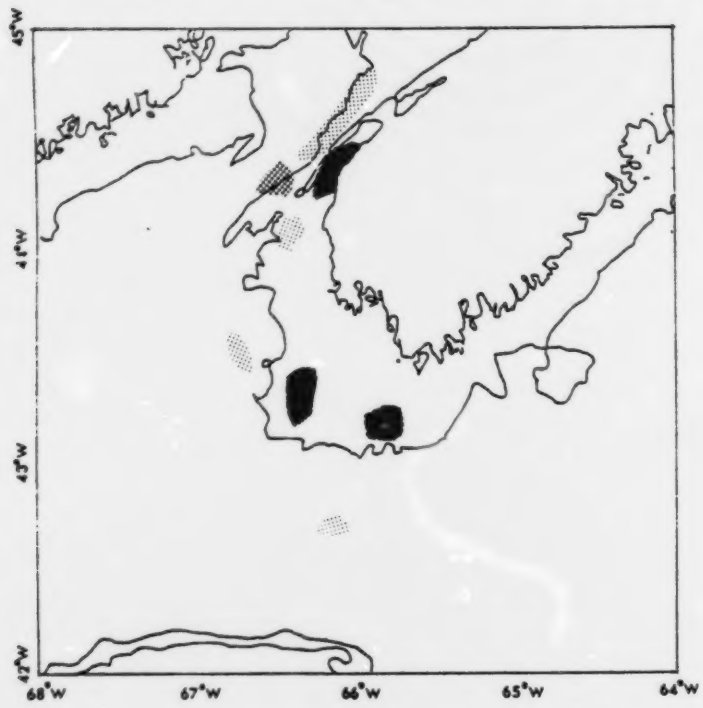

Figure 16. Distribution of observed 1982 winter flounder catches for TC 1-2 vessels.

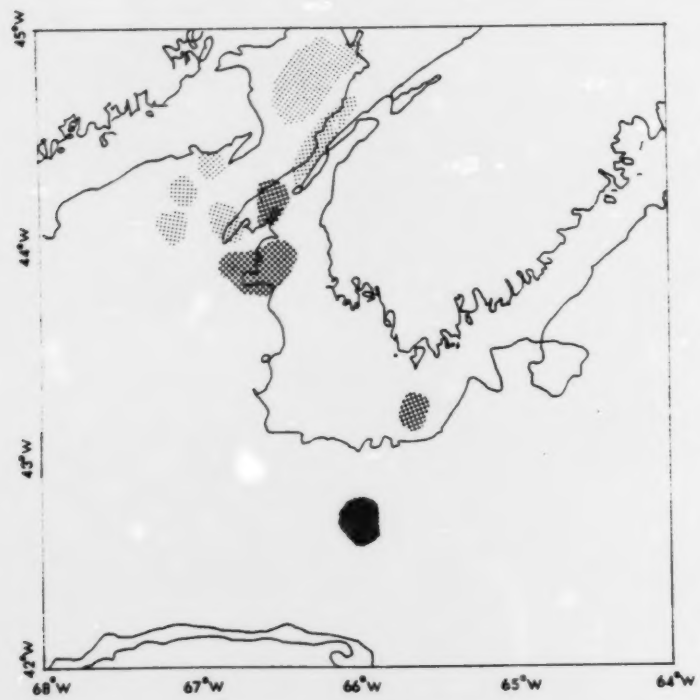

Figure 17. Distribution of observed winter flounder catches (kg/tow) for TC 3 vessels during the 1982 4X study.

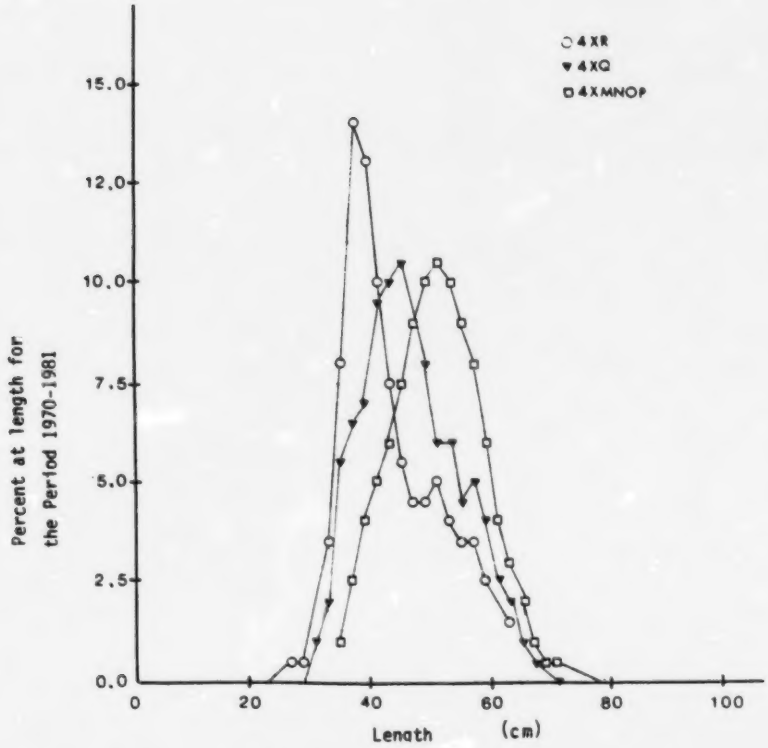

Figure 18. Length composition of landed commercial haddock (1970-1981) from samples collected by port technicians.

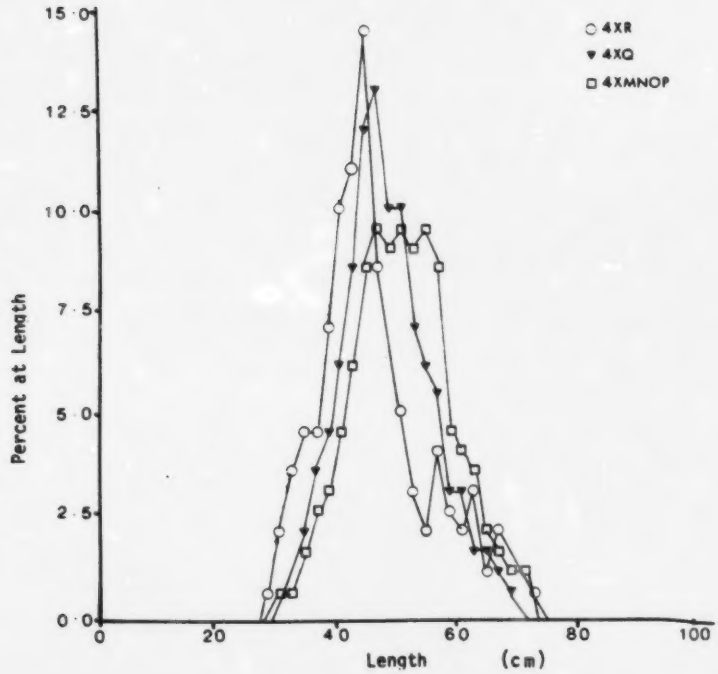

Figure 19. Length composition of landed commercial haddock (1982) from samples collected by port technicians.

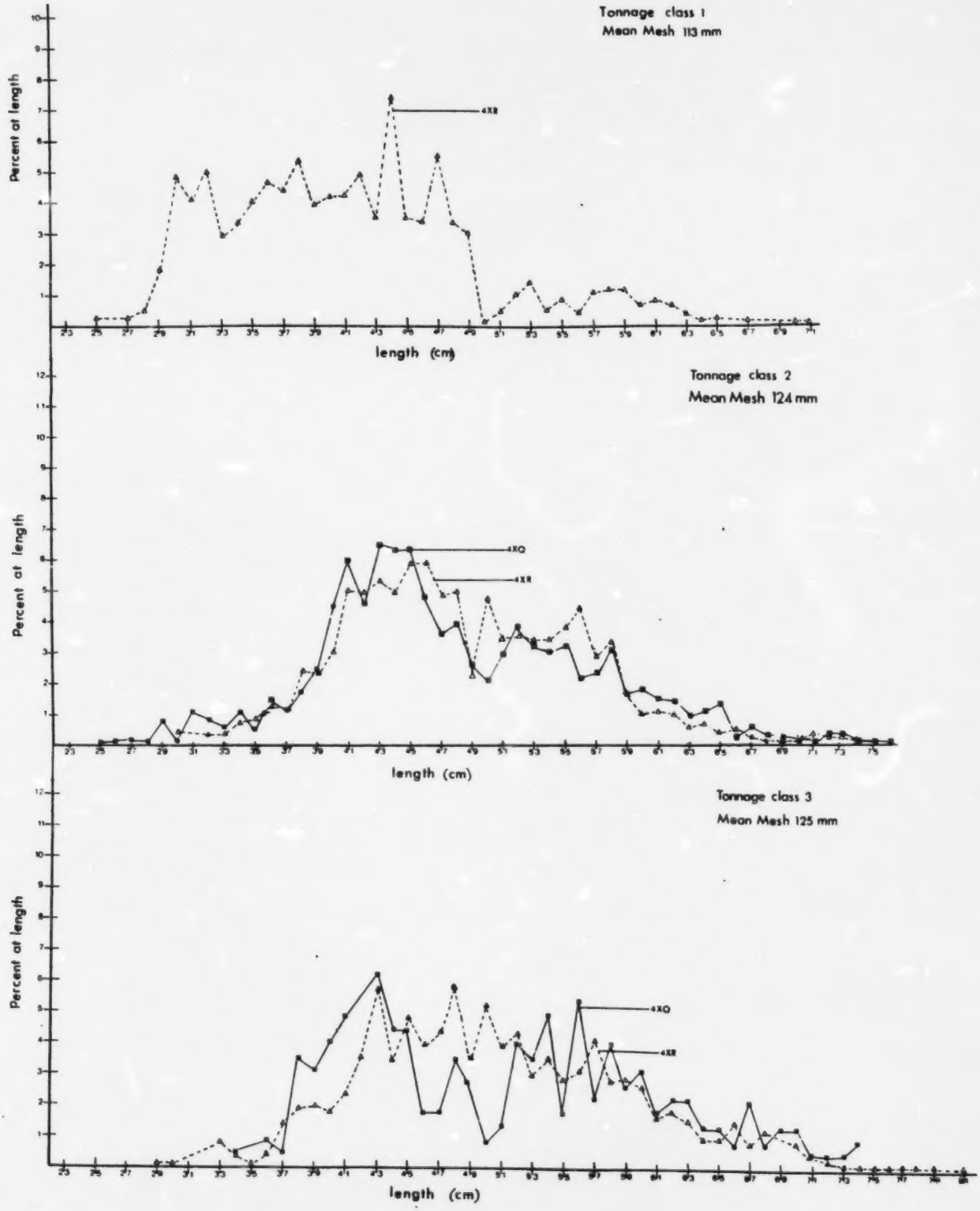

Figure 20. Length composition of 4X haddock samples collected by observers for each tonnage class in 1982.

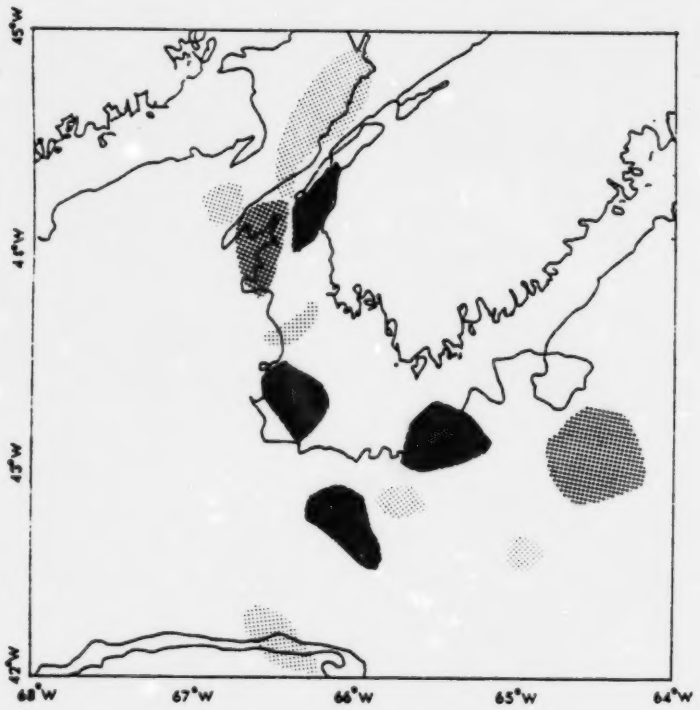

Figure 21. Distribution of age 2 haddock observed during 1982 4X haddock study.

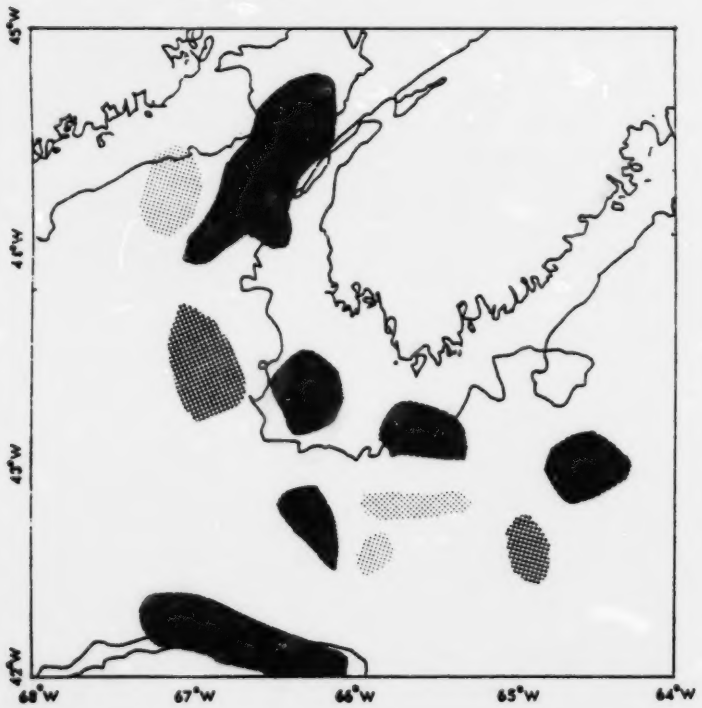

Figure 22. Distribution of age 5+ haddock observed during 1982 4X haddock study.

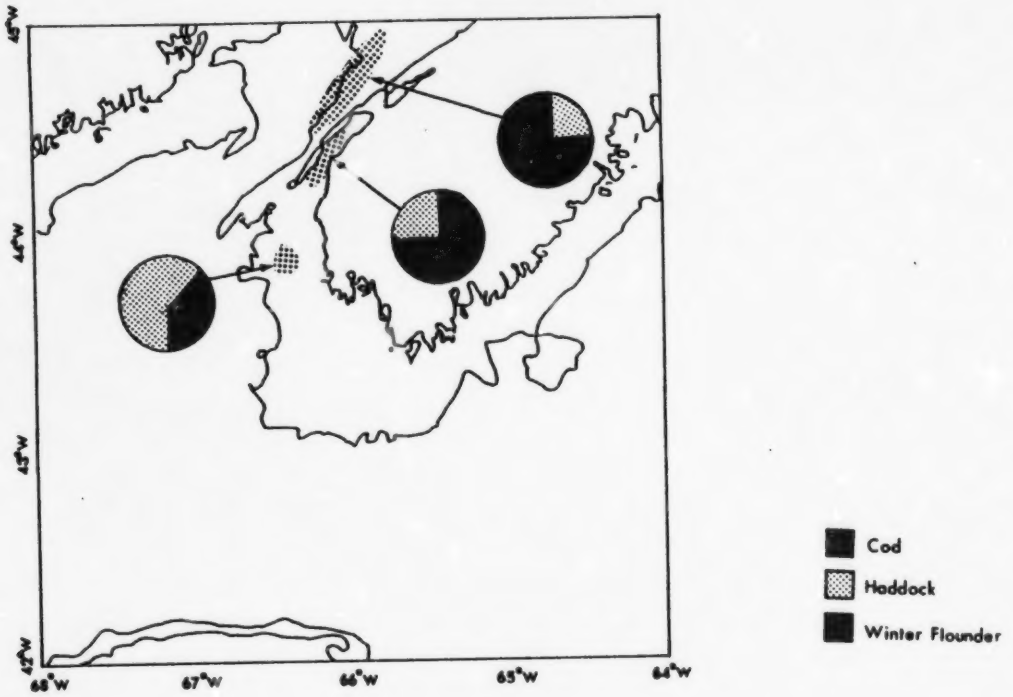

Figure 23. Distribution of observed cod, haddock and winter flounder by TC1 vessels resident in St. Mary's Bay in 1982.

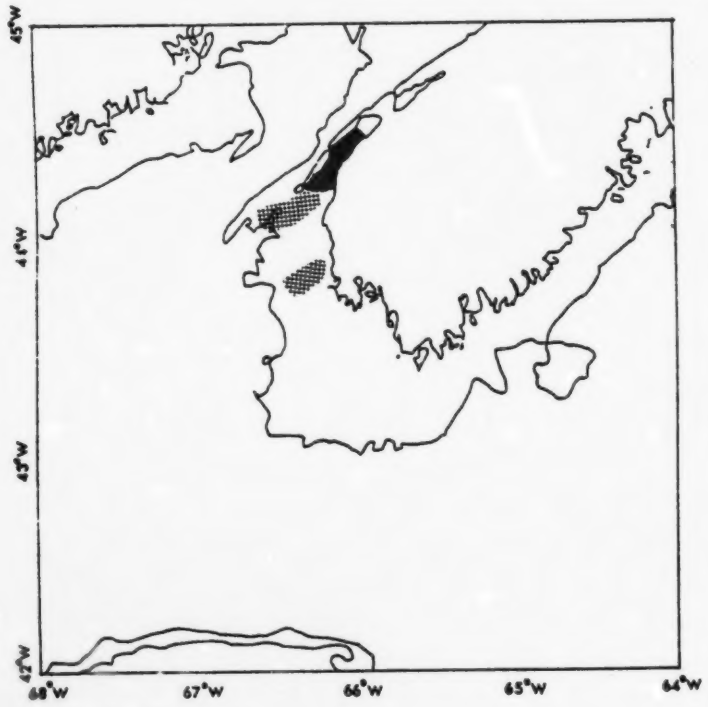

Figure 24. Observed haddock catches by TC 1 vessels resident in St. Mary's Bay.

Appendix A

ECONOMIC IMPACT OF ENFORCEMENT OF A 130MM MINIMUM MESH SIZE REGULATION FOR OTTER TRAWLERS IN 4X

by

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In early 1982, the Department of Fisheries and Oceans consulted fishermen on the matter of increasing the minimum mesh size permitted for otter trawling in NAFO Division 4X from 120 mm to 130 mm. As a result of this consultation, the Department agreed to further study the implications of this change for the haddock fishery. This report follows and is intended to complement an evaluation of the mesh size issue from a biological perspective.

The assessment examines first the overall impact on the 4X fishery, which is relevant primarily to processors in the short-term, but which will determine the availability of fish to fishermen over the longer term. The immediate impact on those fishermen currently using smaller mesh is then estimated by examining costs and earnings data for six small groups of vessels.

Overview

Table A1 illustrates, by statistical district, the relative importance of each species caught by small mobile vessels to the local supply of groundfish. The haddock component of the total groundfish supply (1981) ranges from a low of 25% in District 32, to 45% in the adjoining District 33. The haddock caught by mobile vessels under 65ft. represents only 9% of total groundfish supply in District 32, and 22% in District 38, with other districts in the 30 - 40% range.

Roughly half of these small mobile vessels already use 130 mm mesh size or larger. Increasing the mesh size on the rest of these draggers is, therefore, not going to have a dramatic impact on total industry throughput, even in the short-term. Waldron has estimated a total first year loss of 898 tonnes from the haddock fishery. This represents 3% of reported 1981 landings of haddock from 4X. Obviously the overall impact on both fishermen and processors is also dependent on what happens to catches of species other than haddock. That information is incorporated into the short-term vessel analysis presented later, but is not available for either the total 4X fishery, or for long-term projections.

Tables A2 and A3 illustrate the relative importance of each of the major species in the 1981 catches of two mobile vessel size classes. For small (<45 ft.) draggers, haddock accounts for roughly half their groundfish landings in all districts except 36 and 38. These two districts cover the flounder fishing area at the head of St. Mary's Bay.

For the 45 - 65 ft. draggers in total, the proportions of cod and haddock in the catch are almost identical to the smaller vessels, but pollock replaces flounder as the third major species.

Longer-Term Impact

Our estimates of the immediate impact of a mesh size increase on vessels rely on the results of actual fishing experiments conducted from vessels of different sizes in a number of different areas in 1982. Estimates of the impact in the second and subsequent years following a change in mesh size cannot be as easily tested. Some fish escaping the first year are caught the following year and so on.

The body of the foregoing report on the biological impact of a mesh size change provides projections of haddock catch for 15 years under present mesh size usage as well as under a 130 mm mesh situation. It is projected that catch will decrease immediately after the introduction of the large mesh, and not recover to the original[1] catch levels until the fourth year. The projected losses and gains in catch by year (at 130 mm) are presented in Table A4. Similar numbers are not available for other species.

The long-term gains expected are very small for a number of reasons:

- only half of 4X haddock is caught by otter trawlers under 65 ft. (DFO catch statistics, 1981);
- only about ¼ of 4X haddock is caught by otter trawlers currently using small mesh. (A survey indicated about half of active otter trawlers under 65 ft. were using small mesh. It was generally believed that vessels over 65 ft. were using 130 mm or larger mesh.);
- most trawlers using small mesh will lose less than 20% of their catch in the first year by moving up to 130 mm.

That is, over 95% of the 4X haddock catch will still be caught, leaving less than 1,000 tons of small fish to generate the expected long-term benefits.

Fishing Effort: If the 130 mm mesh is implemented, there could be an increase in fishing effort which might result in a full recovery of losses which would otherwise have occurred. Should this happen, the long-term catch would remain essentially stable, but total effort would rise initially, then fall back to pre-130 mm levels as the benefits of releasing the small fish take effect. The impact of effort increase on

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[1] Actual catches will be more dependent on other factors than on mesh size. The terms "original catch" or "base-level catches" are used here to mean the weight that would be caught if the mesh sizes in use were not changed.

vessel earnings in the short-term is discussed later.

Value of the Long-Term Impact

The mesh size increase represents an investment by the industry in the sense that some of the catch will be given up in order to catch more of it in future. A standard procedure for evaluating this sort of investment is by calculation of the "present value" of the present and future costs to be incurred and benefits to be gained. It could be a better investment for fishermen, for example, to catch the ½ million dollars worth of small haddock next year with small mesh, and invest that money elsewhere rather than wait for it to yield a return through future haddock catches.

By "discounting" costs and revenues[2] at the rate of return provided by the next best alternative investment, the present value enables a comparison of alternatives. Excluding the effects of inflation, an appropriate rate of return might be in the order of 5% for such a private investment. The costs and benefits (value of losses and gains) have therefore been discounted at a rate of 5% (and also at 10% for comparison; see Table A4) to roughly gauge whether moving to 130 mm is a worthwhile investment. (The result would be essentially the same if fish prices were assumed to rise due to inflation, because then a higher discount rate would be necessary to represent interest rates.)

Table A4 takes the estimated gain in yield over 14 years, applies a rough landed price of $500 per metric ton, and discounts this annual value at 5% (and 10%) per annum. The sum of the right-hand column is the present value of the differences in haddock landings over 14 years due to an increase in mesh size.

Extension of the benefit stream (at $88,500 per year) up to the 25th year yields a net benefit of $454,000 at 5% (or $19,000 at 10%) for the total 25 year period. Considering the necessary roughness of the estimates, the small projected net gains over 14 years or even 25 years have no significance in relation to a total landed value of 4X haddock of $15 million per year. That is, the mesh size increase is expected to have no measurable long-term impact on the 4X haddock fishery as a whole.

It should be noted that the long-term calculations have been based on the landed value of haddock, not on the net income position of vessels in the fishery. Although all the fishing costs of the increase will be borne by those draggers now using mesh size under 130 mm, the benefits will be shared by all gear categories, vessel sizes, and geographic areas.

The long-term impact of the mesh size increase on vessels in a mixed fishery will depend on what happens to other stocks, especially cod, as a result of allowing young fish to escape.

Impact on Processing Plants

The overall loss of 4X haddock in the first year of a mesh size increase (without changing effort) will be about 3% (at present effort levels). Although more precise estimates are not available, we might assume that losses of cod will be smaller because proportionally less cod is caught by otter trawls.

Processors in general in Western Nova Scotia will therefore have only marginally less fish available even if fishermen do not maintain catches by increasing fishing effort. Small plants dependent on specific local fleets will, however, be more vulnerable. The net effect on each plant will vary considerably and would require a financial analysis of each operation to determine. However, it is possible to discuss in general terms the direction and magnitude of the impact on plants.

As a part of the haddock mesh size studies, a number of processors in Western Nova Scotia were interviewed to assess implications of a possible change in size composition of fish landed.

If processors offered different prices to fishermen for haddock of different sizes, they might be relatively indifferent as to size of fish purchased. Larger fillets are generally in greater demand in the wholesale market and command better prices, but competition among processors for large haddock would bid up the fisherman's price.

In reality, competition has developed in a different way. Excess capacity in the processing industry has led to processors competing for "fishermen" rather than simply fish. Any load of fish rejected by a processor, or for which a lower price is offered due to size or quality, can be sold to a competitor who hopes to thereby earn the loyalty and steady future deliveries of fish by that fisherman. With this philosophy prevailing in the inshore fishery, a flat price is generally paid for haddock, regardless of size. With the price per pound for raw material the same for large or small haddock, and with better yields and better marketability for larger fish, most processors understandably supported a move towards larger mesh sizes.

The survey of processors produced some reported average yields on haddock fillets based on size (see Table A5), which clearly favoured larger fish (yield varies from plant to plant for a variety of reasons). The differential in labour, packaging and overhead costs per pound of throughput for the above size categories was not easily quantified by the processors interviewed.

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[2] One dollar paid or received a year from now if discounted at 10%, has a present value (value today) of 90.9 cents. In other words, 90.9 cents invested today at 10% interest would become $1.00 a year from now. Discounting can be done for any period of time, but values beyond 25 or 30 years into the future, discounted at 5 or 10%, become very small and usually have little influence on investment decisions.

The survey of processors indicated that most groundfish processors in Shelburne and the southern portion of Yarmouth County will not be as affected as plants in other areas by the establishing of this regulation due to their marginal dependence on vessels presently using less than 130 mm mesh. The processors in Northern Yarmouth County and Digby County will be more affected by the proposed implementation of the regulation. However the direction and magnitude of the impact will vary significantly from plant to plant and will be affected by the manner in which the regulation is implemented. The extent to which plants depend on vessels using less than 130 mesh varies. The groundfish processed by these plants is predominantly haddock, cod and winter flounder. There are a few small processors in St. Mary's Bay (primarily feeder plants) which are highly dependent on flounder and are naturally very concerned if this proposed regulation will also apply to a directed flounder fishery.

The survey indicated that in the short-term, plants located outside the St. Mary's Bay area, supplied primarily by vessels over 45 ft. in length, would not be significantly affected by the proposed regulation. The amount of large and medium haddock and cod will change only marginally with the major portion of the loss being in small fish. In the longer term, these plants may be marginally better off as total haddock catches return to present levels, but with proportionally fewer small fish.

Immediate (First-Year) Impact on Vessels

A sample of 27 vessels owners was interviewed in the area from Cape Sable Island to Digby. Of these, 22 were using small-mesh gear. They provided information on 1981 fishing patterns, effort, and fixed and variable costs of fishing. Landings and landed value information for 1981 from DFO catch statistics was also assessed.

The survey vessels were grouped according to home port, vessel length and areas fished, resulting in six distinct groups being formed. It was assumed that these six groups represented the major components of the dragger fleet that were using less than 130 mm mesh in 1981.

The 1981 costs (operating, maintenance and repairs and fixed costs) were averaged and net returns to labour and vessel were calculated for each group. Summaries of this information are presented in Tables A6-A11. In order to assess the impact on these groups of changing the mesh to 130 mm, information on catch (size composition, location, total landings) expected with 130 mm was provided by the Marine Fish Division. Total expected landed value was then computed and an estimate made of expected returns to these six groups (with the implementation of the 130 regulation in 4X).

Information from the fishing surveys provided necessary information on the expected catch per unit effort with an increased mesh size. The overall impact in terms of fish caught and net income will be dependent on what happens to effort. Two alternate scenarios will be considered.

Scenario 1

Faced with lower catch rates as a result of using larger mesh, fishermen may possibly increase effort in an attempt to maintain total catches. They may increase time per tow, tows per day, days per trip, trips per month, etc.. If quota closure would limit fishing late in the year in a small mesh situation, then use of large mesh will allow fishing later in the year due to the escapement all season of smaller fish.

A possible outcome of a new mesh size regime is the same weight of fish caught as with small mesh, a larger average size of fish and an increase in effort. A decrease of e.g. 20% in catch per unit effort can be made up by an increase of 25% in total effort assuming the larger fish is available[3]. Any possible effects on TAC recommendations as a result of catching larger fish and increasing effort in the short-term have not been considered in this section.

Net incomes will decrease in this case as gross income increases slightly (larger fish with anticipated higher unit value), but operating costs increase in proportion to effort. In reality, costs will probably increase faster than fishing effort as vessels range farther in search of fish.

Scenario 2

If fishing effort does not increase during the fishing season, and especially if the quota would not (under small mesh rules) have been reached sufficiently early to constrain fishing, then large mesh will not allow more effort at season's end. The result in this case will be no change in fishing effort but a decrease in catch of small fish and no corresponding increase in catch of larger fish. The gross and net incomes of vessels will decrease.

Other Scenarios

The table of earnings and costs presented are based on fishing in the same areas and directing for the same species as in 1981 (for costs and income) or in 1982 (for catch per unit effort). Fishing conditions (availability, size distribution, markets, etc.) are assumed to be the same from 1981 into the future. In reality, most vessels, particularly the more mobile ones, will make adjustments in fishing patterns to avoid losses in net income. Predicting future catches is further complicated by the changing local abundances of fish from season to season, changes in relative prices of different species, the effects of closures and by-catch allowances for other species, and so on.

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[3] This is a rough approximation which does not take into account decreasing catch rates as effort increases.

Results

The results depicted for the 40 ft. St. Mary's Bay draggers (Table A6) are sufficiently different from the other groups to warrant special consideration. Revenues for these vessels in the first year after deduction of insurance and operating and maintenance costs are projected to decrease 43% from the 1981 level (excluding inflation) if effort does not increase. After interest and depreciation considerations, income to be shared by the vessels and crew may decrease by half. Vessel sample groups from other ports are not expected to suffer as severe a financial setback. Losses before interest and depreciation will range from 8 to 24% in the static-effort case, and from 3 to 14% with effort adjustment sufficient to fully recoup losses in weight of fish. The extreme cases (24% and 14%) occur in the 57 ft. Saulnierville/Meteghan group where the sample from which financial data was obtained is suspected to be not a good representaton of the fleet (see NOTE following Table A9).

Price Differentiation by Size of Fish

Groundfish purchased from 4X inshore (under 100 ft.) draggers is not generally sorted by size when purchased. Prices are paid for the load (by species) and any price differentiation by size is not explicit. The vessel data was analyzed on the basis that there is an implicit size factor in the haddock and cod prices and for that reason, the average price paid would tend to increase when larger fish are landed.

Based on observations of practices in vertically-integrated offshore fisheries it seemed that a 3¢ variation was reasonable between each of three sizes: small (17"), medium (17-24"), and large haddock. The calculations of value of sales used in the two scenarios in Tables A6 to A11 were based on these assumed price differentials for cod and haddock. The Scenario 1 column in these tables shows the effect of the 3¢ differentials applied to the 1981 catch, but with the substitution of large fish for small fish due to the 130 mm mesh. The effect in each case was an increase in landed value in the 1% range.

The pricing exercise was repeated with an assumed 5¢ differential from small to medium and medium to large. The effect on the catch value was greater than at 3¢, but still only in the range of 2% above 1981 value. As occurred in the long-range impact on catch, it is concluded that the relatively minor adjustments in catch composition will not have a noticeable impact on the landed value of groundfish.

Conclusions

An increase in mesh size for otter trawlers represents an investment in the sense that immediate income is surrendered with the expectation that there will be a future return which will more than compensate for the short-term loss. In the common-property fisheries context, it will not pay an individual to release small fish as an investment, although he may save on culling fish or get a better price if buyers are selective. A mesh size regulation then, may be expected to be equitably based in that all those who will benefit in the long-term should share in the short-term costs. To date, half of the draggers in 4X under 65 ft. in length have not been contributing to the long-run benefit.

As most groundfish in 4X is caught by trawlers already using 130 mm or by longliners, the overall impact of bringing the other draggers up to 130 mm will not be great. An analysis based on bringing these vessels up to 130 mm trawl mesh indicates that there are, unfortunately, no significant long-term advantages (in the haddock fishery only) to increasing mesh size for these vessels.

From the point of view of individual vessels, short-term losses in gross revenue are estimated to be at most 5% to 12%, with one serious exceptional group in St. Mary's Bay. After expenses, net losses will be greater. Although the sample sizes on which these conclusions were reached have been very small, there are no obvious reasons to expect different conclusions from further study.

Little can be said about the impact on processors, except that they can draw on fish from a relatively wide area if necessary, and are not necessarily reliant on trawlers. Processors generally favour handling larger fish, stating that profits on small fish are small or even negative. A few small operators along St. Mary's Bay specialize in small haddock and flounder; these should be considered in conjunction with the special case presented below.

The principal options appear to be either to move to a 130 mm mesh or to revert to a 120 mm minimum. The issue is complicated by the fact that, at present, the fishery is somewhere between the two limits. Legalizing a 120 mm mesh allows the possibility that all vessels currently using 130 mm could revert to 120 mm. The comparisons that have been made compare the hybrid status quo to the 130 mm option. The biological information available, particularly on the 4X cod stock(s), does not permit a good analysis of the long-term implications of either 120 or 130 mm.

For the following reasons, it is recommended that the 130 mm minimum mesh be implemented and enforced for otter trawlers in 4X.

- About half of the small dragger fleet (under 65') is already using 130 mm or larger mesh.
- The adverse short-term impact of switching from current mesh to 130 mm can be avoided to some extent by changing fishing patterns and/or by increasing effort.
- Vessels which will suffer most are those presently using mesh smaller than the existing legal minimum of 120 mm.
- The potential impact of a large-scale return from larger mesh to 120 mm is unknown. If a minimum is to be chosen for application to all vessels fishing 4X, the 130 mm presents less

risk than does 120 mm.

- The 4X haddock fishery cannot be isolated from 4X cod and pollock fisheries, or from adjacent fishing zones.

- No net financial positions can be forecast for processors. Following an adjustment period when less fish in total may be available, processing costs will be reduced due to the larger average size of fish.

Special Case

The small vessels fishing in St. Mary's Bay may require special consideration for a number of reasons:

- These vessels direct for and catch primarily flounder, with an expected 27% loss in value of that species in the first year of a 130 mm regime; no longer-term projections have been made for flounder.

- The net income of these vessels, in the short-term at least, will be cut roughly in half.

- Eleven of the 12 vessels in the inner end of St. Mary's Bay are 38 to 40 ft. in length and those interviewed claim to be incapable of fishing outside the Bay.

- St. Mary's Bay in recent years has been closed to all draggers after early to mid-November. This prevents any attempts to make up a loss in catch through increased effort late in the year.

- The view is held by some biologists that the Bay may be a "nursery" area which attracts primarily young haddock. If this were true, an increase in mesh size would result in a serious income loss even in the long-run.

For these reasons as well as the dependence of a small number of processors on these vessels, we recommend that an exception to the 130 mm regulation be considered for the small St. Mary's Bay vessels fishing flounder within the Bay.

Table A1. Landings by species by small mobile vessels, as percent of total groundfish landed, by district, 1981.

Statistical District	Species	Mobile Gear 45 ft.	Mobile Gear 45-64 ft.	Fixed Gear + Large Mobile	All Vessels All Gears
District 32	Cod	2	1	44	47
	Haddock	6	3	16	25
	Pollock	1	1	4	6
	Flounder	2	-	-	2
	Other	1	1	18	20
	All Groundfish	12	6	82	100
District 33	Cod	12	4	7	23
	Haddock	30	12	3	45
	Pollock	3	1	2	6
	Flounder	12	3	1	16
	Other	5	3	2	10
	All Groundfish	62	23	15	100
District 34	Cod	5	6	14	25
	Haddock	16	15	1	32
	Pollock	1	18	4	23
	Flounder	5	1	1	7
	Other	5	1	7	13
	All Groundfish	32	41	27	100
District 36	Cod	6	23	-	29
	Haddock	6	35	-	41
	Pollock	1	3	-	4
	Flounder	12	8	-	20
	Other	-	5	1	6
	All Groundfish	25	74	1	100
District 37	Cod	8	13	9	30
	Haddock	10	21	3	34
	Pollock	3	20	3	26
	Flounder	2	-	-	2
	Other	1	2	5	8
	All Groundfish	24	56	20	100
District 38	Cod	17	19	8	44
	Haddock	6	16	5	27
	Pollock	1	9	3	13
	Flounder	9	2	-	11
	Other	1	2	2	5
	All Groundfish	34	48	18	100

Table A2. Species composition of groundfish catch for mobile vessels less than 45 ft. (in percent) [1981].

Statistical District	Cod	Haddock	Pollock	Flounder	Other	Total Groundfish
32	21	49	7	13	10	100
33	20	47	5	19	9	100
34	17	52	5	17	9	100
36	23	23	2	46	6	100
37	33	43	12	9	3	100
38	49	16	3	26	6	100
SUM.	24	43	7	19	7	100

Table A3. Species composition of groundfish catch for mobile vessels 45-64 ft. (in percent) [1981].

Statistical District	Cod	Haddock	Pollock	Flounder	Other	Total Groundfish
32	21	48	9	6	16	100
33	17	52	5	15	11	100
34	14	36	44	3	3	100
36	31	48	4	10	7	100
37	24	38	36	1	1	100
38	39	32	19	5	5	100
SUM.	25	43	21	6	5	100

Table A4. Estimates of the present value of future changes in haddock catch.

Year	Gain in Yield* (t round haddock)	Value at $500/t ($)	Discounted at 5% ($)	Discounted at 10% ($)
1	-898	-449,000	-427,619	-408,141
2	-776	-388,000	-351,927	-320,488
3	-165	-82,500	-71,267	-61,958
4	337	168,500	+138,625	+115,086
5	369	184,500	144,561	114,575
6	318	159,000	118,648	89,676
7	317	158,500	112,643	81,311
8	256	128,000	86,636	59,776
9	225	112,500	72,518	47,700
10	207	103,500	63,540	39,951
11	188	94,000	54,960	32,900
12	177	88,500	49,280	28,232
13	177	88,500	46,933	25,665
14	177	88,500	44,699	23,276
Sum of benefits less costs, at face value:		454,500		
Discounted present value of 14 years at 130 mm:			+82,230	-132,439
Discounted present value of 25 years at 130 mm:			+453,514	+19,075

* Based on differences between catch projections at 130 mm and at present mesh size. The differences are so small in relation to the size of the fishery (30,000 t), that they represent no significant changes in overall catch.

Table A5. Processors' survey estimates of yield by size of haddock.

Size (inches)	Yield (%) (from round)
12 - 17	30
18 - 21	32
22 - 25	35
over 25	36

Table A6. Average vessel costs and earnings under alternate fishing scenarios.

Vessel Group:	1	Tonnage Class:	1
Base:	New Edinburgh & Weymouth	Crew Including Skipper:	2
Vessel Length:	40'	Number of Trips in 1981:	79 (1 day trips)

	(111 mm) Small Mesh 1981 Record	130 Scenario 1 More Effort, Same Wt. Fish	130 Scenario 2 Same Effort, Less Fish
Landed Value	55,628	55,786	38,176
% Change			-38%
Operating Costs	9,298	14,396	10,098
Fixed Costs	3,450	3,450	3,450
Cash Income Before Interest Payments	42,880	37,940	24,628
% Change		-12%	-43%
Opportunity Cost of Capital*	4,560	4,560	4,560
Depreciation	5,069	5,069	5,069
Net Return to Vessel and Labour**	33,251	28,311	14,999

* Approximate interest paid on borrowed capital or interest foregone if asset is owned by the fisherman.

** Judged to be less significant than cash income in considering short-term impact of mesh size increase.

Table A7. Average vessel costs and earnings under alternate fishing scenarios.

Vessel Group:	2	Tonnage Class:	2
Base:	Digby, Meteghan, Little River	Crew Including Skipper:	3
Vessel Length:	44' 11"	Number of Trips in 1981:	64 (2 day trips)

	(120 mm) Small Mesh 1981 Record	130 Scenario 1 More Effort, Same Wt. Fish	130 Scenario 2 Same Effort, Less Fish
Landed Value	134,122	135,603	117,840
% Change			-12%
Operating Costs	56,400	65,412	57,200
Fixed Costs	3,450	3,450	3,450
Cash Income Before Interest Payments	74,272	66,741	57,190
% Change		-10%	-23%
Opportunity Cost of Capital*	13,800	13,800	13,800
Depreciation	15,341	15,341	15,341
Net Return to Vessel and Labour**	45,131	37,600	28,049

* Approximate interest paid on borrowed capital or interest foregone if asset is owned by the fisherman.

** Judged to be less significant than cash income in considering short-term impact of mesh size increase.

Table A8. Average vessel costs and earnings under alternate fishing scenarios.

Vessel Group:	3	Tonnage Class:	3
Base:	Little River	Crew Including Skipper:	3
Vessel Length:	63'	Number of Trips in 1981:	36 (3 day trips)

	(122 mm) Small Mesh 1981 Record	130 Scenario 1 More Effort, Same Wt. Fish	130 Scenario 2 Same Effort, Less Fish
Landed Value	197,559	199,078	185,379
% Change			-6%
Operating Costs	87,217	93,967	88,817
Fixed Costs	5,867	5,867	5,867
Cash Income Before Interest Payments	104,475	99,244	90,695
% Change		-5%	-13%
Opportunity Cost of Capital*	22,980	22,980	22,980
Depreciation	25,546	25,546	25,546
Net Return to Vessel and Labour**	55,949	50,718	42,169

* Approximate interest paid on borrowed capital or interest foregone if asset is owned by the fisherman.
** Judged to be less significant than cash income in considering short-term impact of mesh size increase.

Table A9. Average vessel costs and earnings under alternate fishing scenarios.

Vessel Group:	4	Tonnage Class:	2 and 3
Base:	Saulnierville, Meteghan	Crew Including Skipper:	3
Vessel Length:	57'	Number of Trips in 1981:	45 (2 day trips)

	(124 mm) Small Mesh 1981 Record	130 Scenario 1 More Effort, Same Wt. Fish	130 Scenario 2 Same Effort, Less Fish
Landed Value	126,219	127,620	115,609
% Change			-8%
Operating Costs	70,650	79,331	72,250
Fixed Costs	4,200	4,200	4,200
Cash Income Before Interest Payments	51,369	44,089	39,159
% Change		-14%	-24%
Opportunity Cost of Capital*	17,280	17,280	17,280
Depreciation	19,210	19,210	19,210
Net Return to Vessel and Labour**	14,879	7,599	2,669

* Approximate interest paid on borrowed capital or interest foregone if asset is owned by the fisherman.
** Judged to be less significant than cash income in considering short-term impact of mesh size increase.

NOTE: After analysis of the costs and incomes data, it was suspected that the three vessels in Group 4 had landed values less than typical vessels in this size range. Landings were obtained for four more vessels of comparable size fishing in the same area. Cost data was available on one of these. While the costs incurred by this vessel were almost identical to the original sample average, average gross income of the second sample was $178,000. This addition of $50,000 to the top line in Group 4 would carry through to the net return at the bottom of Table A8 yielding a more plausible bottom line for these vessels. The percent losses would then be comparable to those of Group 3.

Table A10. Average vessel costs and earnings under alternate fishing scenarios.

Vessel Group:	5	Tonnage Class:	1 and 2
Base:	Pembroke/Yarmouth	Crew Including Skipper:	3
Vessel Length:	43'	Number of Trips in 1981:	27 (3 day trips)

	(123 mm) Small Mesh 1981 Record	130 Scenario 1 More Effort, Same Wt. Fish	130 Scenario 2 Same Effort, Less Fish
Landed Value % Change	79,862	81,129	70,218 -12%
Operating Costs Fixed Costs	15,800 800	21,213 800	16,600 800
Cash Income Before Interest Payments % Change	63,262	59,116	52,818 -17%
Opportunity Cost of Capital*	5,100	5,100	5,100
Depreciation	5,670	5,670	5,670
Net Return to Vessel and Labour**	52,492	48,346	42,048

* Approximate interest paid on borrowed capital or interest foregone if asset is owned by the fisherman.

** Judged to be less significant than cash income in considering short-term impact of mesh size increase.

Table A11. Average vessel costs and earnings under alternate fishing scenarios.

Vessel Group:	6	Tonnage Class:	2
Base:	Pubnico	Crew Including Skipper:	3
Vessel Length:	44'	Number of Trips in 1981:	28 (3 day trips)

	(127 mm) Small Mesh 1981 Record	130 Scenario 1 More Effort, Same Wt. Fish	130 Scenario 2 Same Effort, Less Fish
Landed Value % Change	138,797	140,023	131,933 -5%
Operating Costs Fixed Costs	44,675 2,025	48,345 2,025	45,475 2,025
Cash Income Before Interest Payments % Change	92,097	89,653 -3%	84,433 -8%
Opportunity Cost of Capital*	13,800	13,800	13,800
Depreciation	15,341	15,341	15,341
Net Return to Vessel and Labour**	62,956	60,512	55,292

* Approximate interest paid on borrowed capital or interest foregone if asset is owned by the fisherman.

** Judged to be less significant than cash income in considering short-term impact of mesh size increase.